SCIENCE

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Editorial Small Country with Big Problems 869

Articles Origin and Migration of Oil: *E. G. Baker* 871

Oil may consist of hydrocarbons that collected from waters containing natural solubilizers.

Resources, Population Growth, and Level of Living: *V. E. McKelvey* 875

A society's wealth depends on the use it makes of raw materials, energy, and especially ingenuity.

Francisco Duran-Reynals, Bacteriologist: *C. C. Little* 881

News of Science Greater Role for United Nations Specialized Agencies Seen in Meeting Problem of Population Outrunning Resources; recent events 882

Book Reviews S. Fabricant's *Basic Facts on Productivity Change*, reviewed by *G. Colm*; other reviews 890

Reports Propagation of Poliovirus, Measles, and Vaccinia in Guinea Pig Spleen Cell Strains: *C. C. Mascoli, L. V. Stanfield, L. N. Phelps* 894

Role of Magnesium in Acetyl Coenzyme A Formation by Acetothiokinase: *P. Berg; L. L. Ingraham* and *D. E. Green* 895

Interaction of Gibberellic Acid and Indoleacetic Acid in *Impatiens: J. Weijer* 896

Drug Metabolism in the Newborn Rabbit: *J. R. Fouts* and *R. H. Adamson* 897

Resistance to Sevin by DDT- and Parathion-Resistant Houseflies and Sesoxane as Sevin Synergist: *M. E. Eldefrawi, R. Miskus, W. M. Hoskins* 898

Multiple Hemoglobins in Fishes: *D. R. Buhler* and *W. E. Shanks* 899

Analysis of Gas in Biological Fluids by Gas Chromatography: *L. H. Ramsey* 900

Tritium Tracer in Arctic Problems: *B. J. Giletti* and *J. L. Kulp* 901

Comparison of the Effects of Delayed Auditory Feedback on Speech and Key Tapping: *R. A. Chase* et al. 903

Great Basin Petroglyphs and Prehistoric Game Trails: *R. F. Heizer* and *M. A. Baumhoff* 904

Departments Letters 864

Space Science; Meeting Notes; Forthcoming Events; Equipment 908

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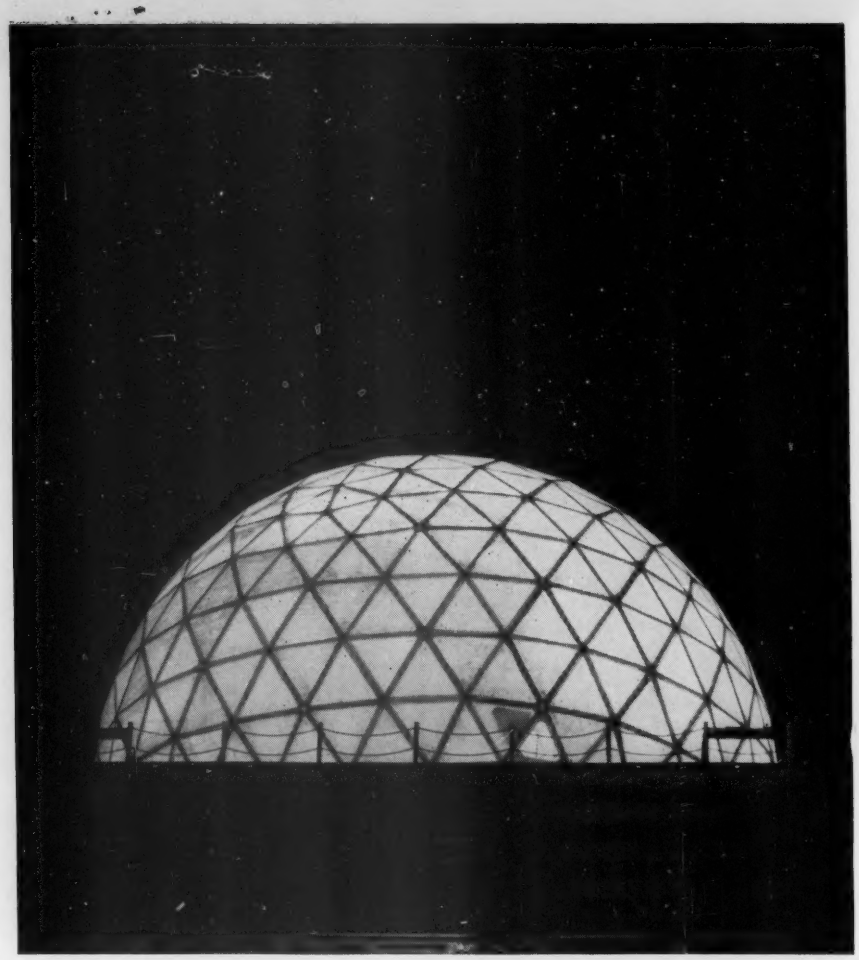

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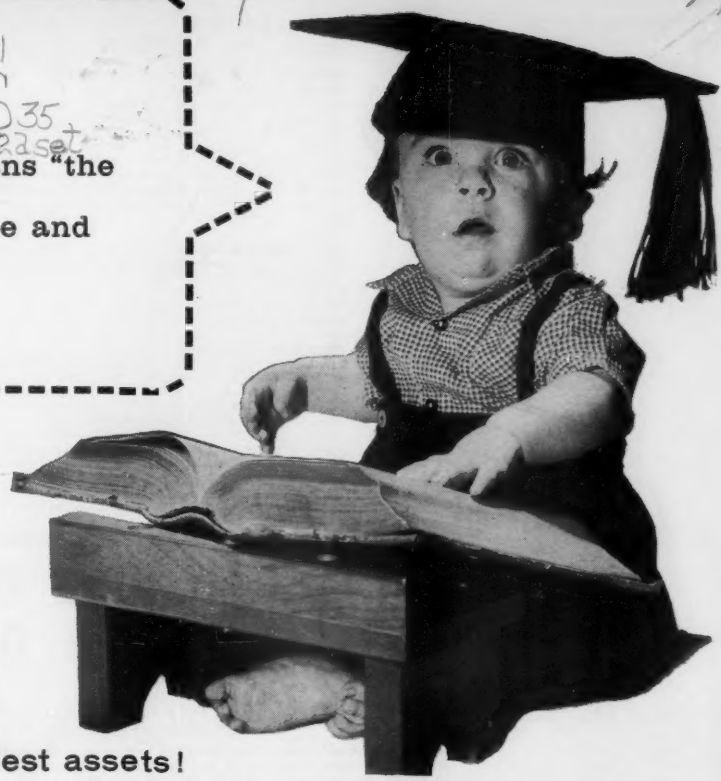

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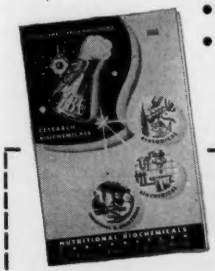

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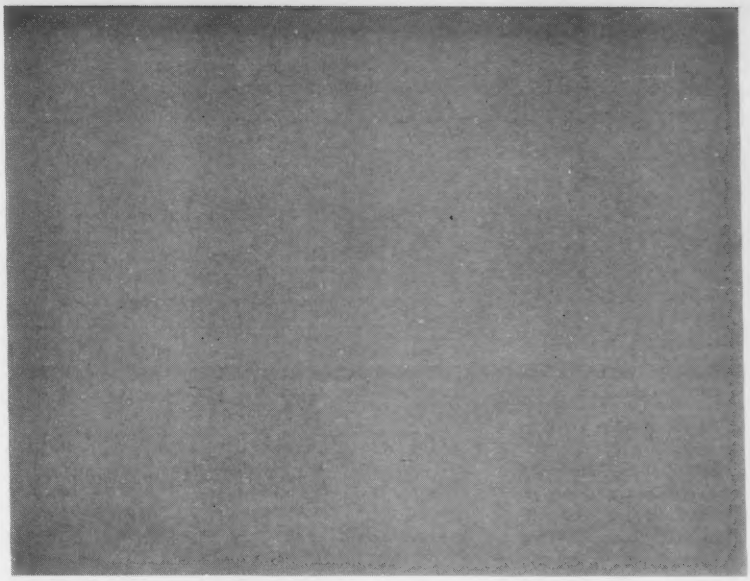

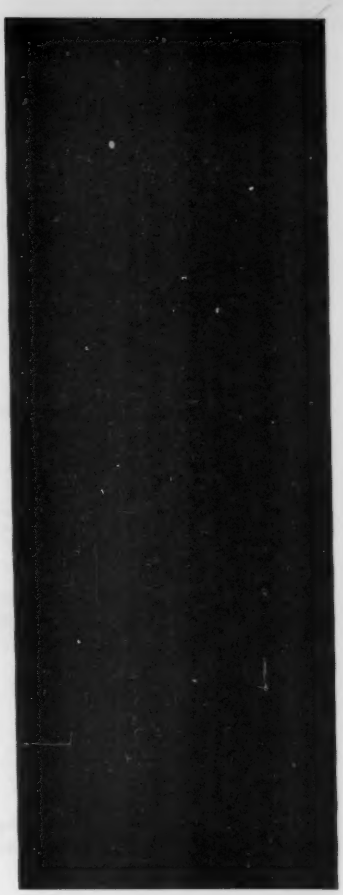

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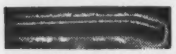

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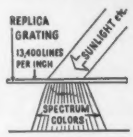

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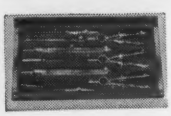

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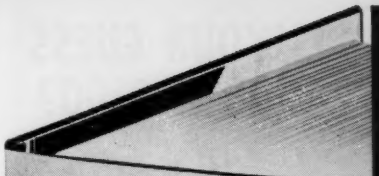

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Letters

Nuclear Tests

I cannot conceal my disappointment, even shame, on reading the pious platitudes of our Council's Resolution on Control of Nuclear Weapons Tests, printed in the issue of 16 January [*Science* **129**, 137 (1959)]. One might rather have expected such a resolution from an association of scientific civil servants, too terrified of losing their jobs to risk offending Dulles and the Atomic Energy Commission. An embarrassed silence would have been preferable to this type of sickening hypocrisy.

Instead of emitting "profound hope that the Geneva Conference negotiations will prove successful," the Council might well have told the world in a clear, straightforward way (i) whether they consider that nuclear bomb test explosions constitute a probable danger to the future of our species; (ii) whether they favor discontinuance of such explosions (that is, *yes* or *no*); (iii) whether they are alarmed at the present situation in which two armed, cynical, irresponsible, and dishonest giants are daily threatening each other and the rest of the world with total destruction; and (iv) how the international scientific community can bring pressure to bear on Tweedledum and Tweedledee to restore calmness and sanity where it is most needed.

J. GORDIN KAPLAN
Department of Physiology, Dalhousie University, Halifax, Nova Scotia

Beneficiation of Soils Contaminated by Strontium-90

I have read with surprise and concern W. F. Libby's report [*Science* **128**, 1134 (1958)] on his experiments which were made, as he says, to test two proposals: (i) that the addition of sulfates to contaminated soils might be helpful in making strontium unavailable for plant nutrition, and (ii) that potassium might have a considerable beneficial effect with respect to absorption of radiostrontium.

I will attempt to justify my surprise on purely technical grounds, for what Libby refers to in his report are not experiments but, at best, "high spot tests," which could not, on any grounds, allow one to arrive at valid conclusions.

The soil is such a complex system that it must be fully characterized before one can undertake to do anything with it. To say that the soil used was taken from a garden in Washington, D.C., and that it had an exchange capacity of 32 milliequivalents per 100 g is utterly useless, if this information was intended to help the scientific reader interpret the sig-

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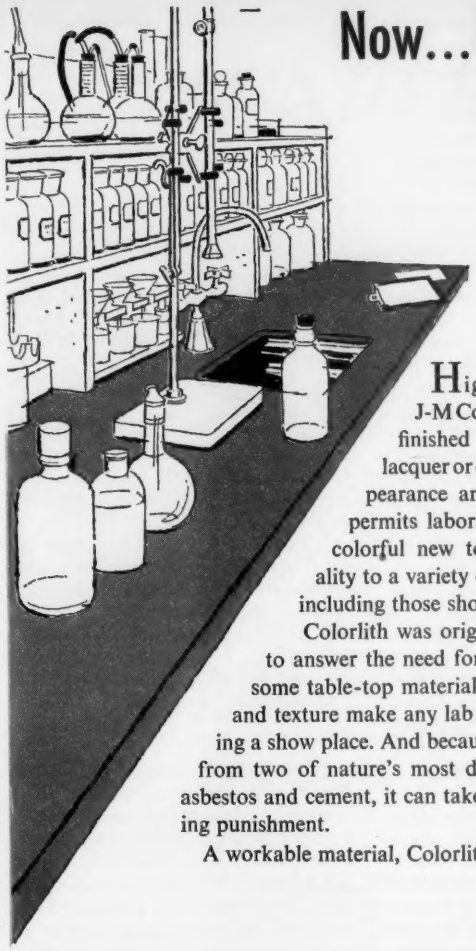

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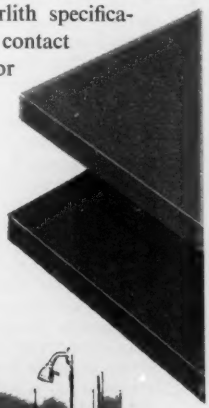

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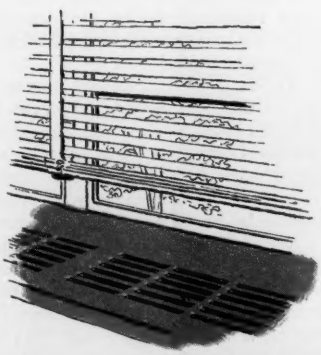

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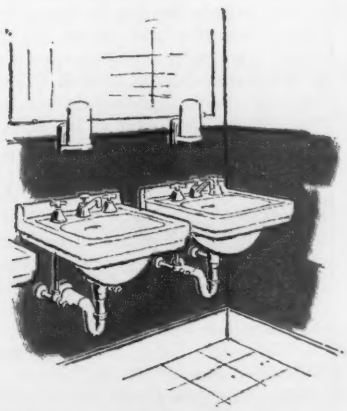

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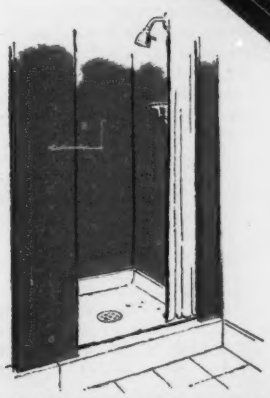

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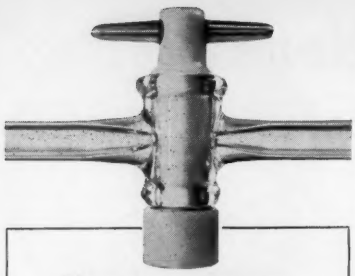

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nificance of the pot tests. Since we should be interested in facts, I would have preferred to see a minimum of basic information on: (i) the ion components of the exchange capacity, particularly K^+, Ca^{+2}, NH_4^+, and Na^+; (ii) the ease of availability of the "native potassium," both by actual chemical tests and by plant growth tests, and (iii) an analysis of the soluble and insoluble sulfates.

This information would have contributed greatly to understanding the significance of Libby's initial additions of the potassium and strontium salts in amounts of about 1 percent of the total exchange capacity of the soil mass used per pot. The lack of this type of information is perhaps understandable, for it still appears to be the exclusive property of that breed of men known as soil scientists.

The tests themselves were faulty, because their design ignored some basic characteristics of the experimental material and disregarded some elementary principles of experimentation.

The soil cannot be treated as if it were a chemical reagent, for, above all, it is a complex entity with its essential characteristics of variability and a sensitive ability to change with the treatments given, and with environment. To control this inherent variation, an essential part of any experimentation with a soil is replication—not just duplication, as is customarily done in a simple titration, but, say, from three to five repetitions for each treatment. Moreover, these treatments should be laid out in accordance with a design that will strengthen the scientist's chances of beating nature!

Libby's claims, I would assume, must be based on a subconscious acceptance of the findings obtained by Peech, Bradfield, Reitemier and others. His data could not support any of his conclusions.

The use of the ABCD type of tests to arrive at conclusions which have a direct bearing on the health of all mankind should be a question of great concern to all responsible people. I was delighted to read front-page newspaper reports about "Dr. Libby's solution of Sr^{90} fallout by adding to the soil potassium fertilizers," only to find out later, with great disappointment, that the claims were totally unwarranted. But, alas, public opinion has been given one more pill of relief.

L. A. Romo

945 Savitt Place,
Union, New Jersey

The recent report by W. F. Libby demonstrates a surprising lack of information on matters that are relatively well known to biologists. It has been known for at least a quarter of a century that potassium in the soil reduces the uptake of calcium, and, since calcium and strontium are so closely related, it would seem obvious that added potassium would reduce strontium uptake from soil. See Fig. 1, which is slightly modified from one that was published in 1933.

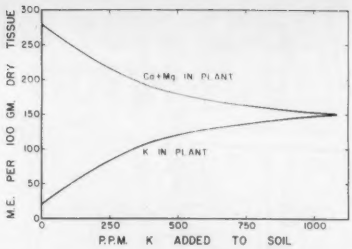

Fig. 1. Ion content of tomato plants as a function of potassium added to soil. [From data of D. R. Hoagland and J. C. Martin, *Soil Sci.* 36, 1 (1933); redrawn by D. R. Hoagland.]

Would it be too much to suggest that the Atomic Energy Commissioners, when confronted with botanical problems, might employ a botanist?

Kenneth V. Thimann
Bruce B. Stowe

Harvard Biological Laboratories,
Cambridge, Massachusetts

I have read with disappointment L. A. Romo's criticism of my article, "Beneficiation of soils contaminated with strontium-90: beneficial effects of potassium." I know well how incomplete the work is, but I hope it has more scientific value than Romo finds in it. Perhaps its best value will be to encourage further research into what is a very important practical problem. The extensive research on radioactive fallout which has been conducted during the past years shows that the type of work I tried to do is urgently needed.

Thimann and Stowe are correct in questioning my knowledge of botany, but I hasten to assure them that the Atomic Energy Commission does employ very capable botanists. It is true, of course, that the effect of potassium on calcium uptake by plants has long been known. The corresponding effect on strontium has not been established so firmly, however, especially for the very low concentrations resulting from radioactive fallout on acid soils.

I hope the work has more merit than the tone of these letters indicates. The problem is a very important one for civilian defense, and it was only after failing to persuade professionals to undertake it that I made this attempt.

I hope Romo and Thimann and Stowe will turn to and do a better job for us all.

W. F. Libby

Atomic Energy Commission,
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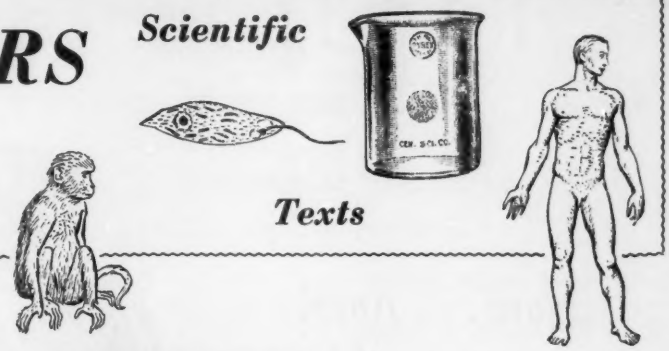

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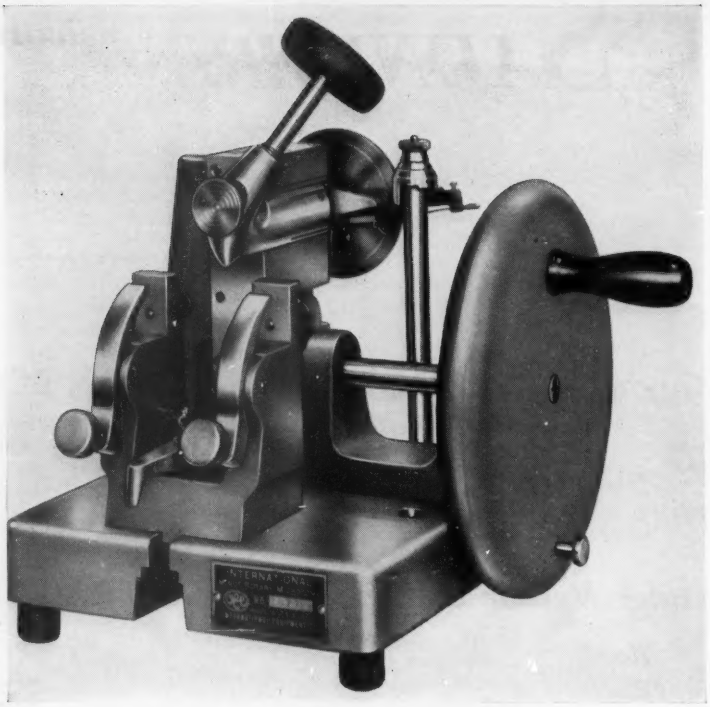

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Small Country with Big Problems

When the Government of Israel invited us to visit their country for two weeks to see whatever might be of interest, we accepted promptly, for we wanted to find out what role science and technology are playing in the Israeli economy.

A fortnight is much too short a time to form a judgment about such matters by direct observation, but it is not too short a time to form many impressions, to correct erroneous preconceptions, and to find out what the scientists and technologists themselves think of as the major problems they face. With the primary aim of concentrating on this last point, we visited several of the major educational and research institutions of the country: the Weizmann Institute at Rehovoth, the Hebrew University at Jerusalem, the Technion (Technical Institute) at Haifa, and the Desert Research Station at Beersheeva.

Aside from its shortages in most of the minerals that provide the basis for industrial production, the country has two dominant needs: energy and water. Israel produces only about 10 percent of the oil it consumes and has no workable deposits of coal. Consequently, power is expensive and Israeli factorics are at a competitive disadvantage. Every avenue of possible supplemental power is being explored: hydroelectric power from the Jordan River on its way to the Dead Sea; windmills of advanced design; and, especially, solar energy. Practical solar devices for heating water for domestic use are already in production, as are solar air conditioners for the desert regions of the country. Industrial production of solar power is still not economical, but a considerable program of research is under way, and with increased efficiency of production, solar power may provide a partial solution to the power shortage. Nuclear power stations will be installed—the first at Elath, which is the southern edge of the Negev Desert—but, like other sources of power in Israel, they will be relatively expensive.

So far as water is concerned, the needs are obvious. The southern two-thirds of the country is composed of the Negev Desert, where wells yield for the most part a brackish water currently unsuitable for agricultural use. The research effort being made to solve the water problem is many-pronged and vigorous. Intensive studies of ground water and ground-water replacement are being made, and studies of runoff and possible surface storage, especially in the desert, and the development of elaborate irrigation schemes form a large and coordinated program. Current resources will permit the irrigation of the northern part of the Negev by water from the Yarkon River north of Tel Aviv, but the great hope lies in the proposed diversion of the waters of the Jordan—an undertaking which at present is politically impossible.

The coordinated attack upon the water problem does not end with irrigation schemes. All feasible ways of desalting water are under study, but so far the product is relatively expensive: if the power requirements are low, the capital costs are high or the output rate is low. Among the schemes being investigated are steam distillation at nuclear power stations, solar distillation, compression distillation, freezing processes, direct filtration, and electrodialysis. But the problem is being attacked from other angles as well. Plants that can tolerate brackish water are being sought, and in one unorthodox proposal, an attempt is being made to modify the salt balance of brackish water by the addition of supplemental salts, thus making it suitable for agriculture.

Israel's needs stand out in sharp relief; science and technology clearly form the indispensable basis for the solution of her economic problems.
—G.DuS.

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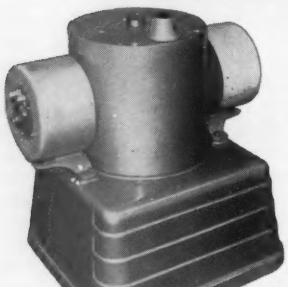

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Origin and Migration of Oil

Oil may consist of hydrocarbons that collected from waters containing natural solubilizers.

E. G. Baker

Although much progress has been made in the past decade, a generally acceptable understanding of the origin of oil is still lacking. Insight into the mechanism of the migration of oil has proved to be even more elusive (*1*). Although the problems of the origin and migration of oil are usually treated as separate subjects, they are, nonetheless, intimately related.

Ever since Smith (*2*) demonstrated the presence of paraffinic, naphthenic, and aromatic hydrocarbons in recent marine sediments, the connection of these hydrocarbons with crude oil deposits has been debated (*3*). However, the main problem is still that of understanding how these highly dispersed sediment hydrocarbons collect to form an oil accumulation (*4*). This is usually referred to as the problem of oil migration, but it is also the problem of the origin of oil. A solution is proposed here—namely, that crude oil deposits consist of sediment hydrocarbons that have migrated in, and collected from, waters containing natural solubilizers. This hypothesis can be evaluated in the light of our growing knowledge of crude oil composition.

Migration in Aqueous Solution

Whatever the mechanism of oil formation, it must be closely associated with the evolution of a sedimentary basin. To investigate this relationship, an experimental program was initiated several years ago by Esso Research and Engineering Company (*5*) to learn whether the hydrocarbons known to be present in Recent sediments could dissolve in and move with the waters expelled from compacting sediments (*6*). Such a process, if hydrocarbons are sufficiently soluble, would enable the highly dispersed hydrocarbons in clay sediments to become concentrated in the more permeable and porous sands and, hence, to form the deposits known as crude oils. In addition to requiring adequate solubilities, this mechanism would require that the hydrocarbons come out of solution and be trapped in the reservoir rock.

Our initial work on hydrocarbon solubilities in ordinary water was expanded by a study of solubilities in dilute colloidal electrolyte solutions. The latter work, by demonstrating greatly increased solubilities, by providing a reasonable mechanism for unloading oil from solution, and—perhaps most significantly—by indicating that a relationship exists between crude oil composition and hydrocarbon solubility, has led to the hypothesis set forth in this article.

Crude Oil Composition

If crude oil did form from hydrocarbons that dissolved in water and then came out of solution, the composition of oil should be related to the solubility in water of the individual hydrocarbons comprising the oil. The logical step is to consider whether the composition of crude oil reflects such a solution mechanism of origin.

Although our knowledge of the composition of crude oil is far from adequate, it is becoming increasingly apparent that crude oil is a far more simple and uniform collection of hydrocarbons than one would have previously imagined. Its simplicity is revealed by the fact that not all of the statistically possible isomers are present in the distillate fractions of oil. The results of an exhaustive fractionation of a representative petroleum by research project No. 6 of the American Petroleum Institute (API) show, for example, that 159 different hydrocarbons account for the lower-boiling 44.5 percent of the original petroleum (*7*). This is truly a remarkable result when it is considered that at least some hundreds of thousands of different hydrocarbons could have appeared in this distillate fraction of the crude oil.

More recently, A. Hood *et al.* (*8*) suggested that a single picture of simplicity applies to the entire distillate range of petroleum and that a predominant portion of the higher-boiling fractions of petroleum also consists of a relatively few simple isomeric molecules. Meinschein (*9*) finds a similar simplicity in the hydrocarbons dispersed in marine sediments. Thus, the simplicity of the composition of crude oil reflects the fact that there were a limited number of different hydrocarbons available in the sediments for collection.

The uniformity in crude oil composition is disclosed by the fact that within a given class of hydrocarbons—say the alkylaromatics or the normal paraffins—the relative amounts of the individual hydrocarbons occur in nearly the same proportions in different crude oils (*10*).

The uniformity in the distribution of homologous hydrocarbons is illustrated in Fig. 1 for the single-ring aromatic hydrocarbons. The amounts of benzene, toluene, ethylbenzene, and *n*-propylbenzene in three widely different crude oils (*11*) are shown as a function of hydrocarbon size, or molar volume. It can be seen that there is always more toluene than benzene in crude oil—even though the oil may be called a paraffinic base crude (the Bradford oil), because paraffin hy-

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Table 1. Comparison of predicted and observed composition of crude oil.

Paraffin	Measured solubilities (vol. parts per billion)		Concentrations in crude oil (vol. parts per thousand)	
	Micelle solution*	Water	Predicted†	Observed‡
n-Decane	34.6	22.0	17.9	18.0
n-Octadecane	11.3	7.75	5.0	5.0
n-Hexatriacontane	2.31	2.09	0.31	0.32

* Micelle solution is composed of Na laurate (0.13 wt percent) plus NaCl (1.0 percent).
† From Eq. 1, with $k = 1.42 \times 10^6$ and $m = 1$.
‡ From data of American Petroleum Institute project No. 6.

drocarbons are predominant, or a naphthenic base crude (the Conroe oil), because cyclic hydrocarbons are predominant.

Because a remarkable similarity within a given homologous series of hydrocarbons exists among various crude oils, even though the hydrocarbons have been produced from widely different environments, it is evident that some common, universal process must have operated that selectively removed hydrocarbons from the source sediments and deposited them in the right proportions in the reservoirs. I suggest that this selective process is the solution and migration of sediment hydrocarbons in waters containing natural solubilizers.

In contrast to this hypothesis of the migration of hydrocarbons in aqueous solution, it has been postulated that hydrocarbons may move en masse from source to reservoir rock. If sediment hydrocarbons could move in a nonaqueous state into the reservoir rock by compaction, the distribution of hydrocarbons in the reservoir, particularly the distribution of the saturated hydrocarbons, would be similar to their distribution in the source sediments. Insofar as the normal paraffin hydrocarbons are concerned, this is not the case. The normal paraffins in sediments, unlike those in crude oil, exhibit a strong preference for odd-carbon-number paraffins (*12*). As is shown below, differences in the distribution of hydrocarbons in sediments and in crude oils are easily understood in terms of the selective nature of the solution mechanism by which the sediment hydrocarbons become concentrated to form oil deposits.

Hydrocarbon Solubility

Our studies of hydrocarbon solubilities in ordinary water and in dilute colloidal electrolyte solutions, such as formation waters, indicate that a relationship exists between crude oil composition and hydrocarbon solubility. For example, the equation

$$C_i = k(S_i - mS_i^\circ) \qquad (1)$$

(where C_i is the volume ratio of the ith hydrocarbon in petroleum, S_i and S_i° are the volume ratio solubilities of the ith hydrocarbon in the colloidal electrolyte solution and in pure water, respectively, and k and m are constants for a given petroleum and colloidal electrolyte solution) relates the concentration of individual hydrocarbons in crude oil to their solubilities in dilute colloidal electrolyte solutions and in pure water. The equation suggests that the abundance of any hydrocarbon in crude oil is determined primarily by its micellar solubility ($m = 1$) and by the effect of subsequent leaching by water ($m > 1$). The constant k is just the reciprocal of the micellar solubility of oil in water containing solubilizers. The dependence of crude oil composition on the micellar solubilities of hydrocarbons is perhaps best illustrated by Fig. 2, which shows the solubility data obtained for benzene, toluene, and *n*-propylbenzene in a dilute sodium naphthenate solution.

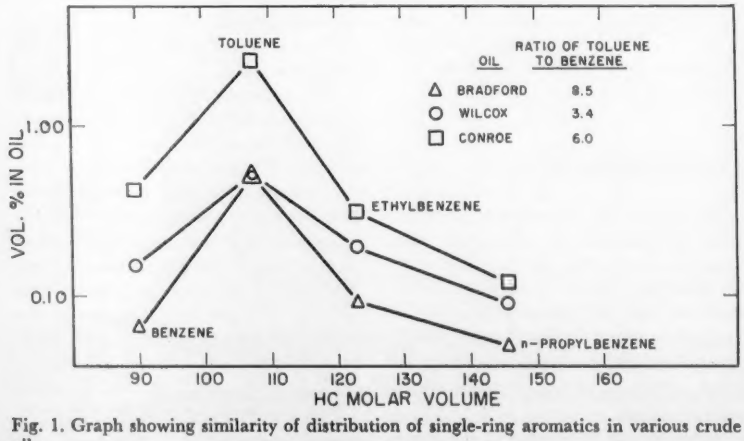

Fig. 1. Graph showing similarity of distribution of single-ring aromatics in various crude oils.

It will be recalled that the distribution of single-ring aromatics in crude oil shows that toluene is always the most abundant hydrocarbon. Figure 2 illustrates that it is not the total solubility of hydrocarbon in the soap solution (upper curve) or the solubility of hydrocarbon in ordinary water (lower curve) that predicts the excess of toluene over benzene in crude oil but, rather, the solubility in soap micelles—the difference between the upper and lower curves.

It has been found, over a wide range of soap concentrations and soap types, that the ratio of the solubility of toluene to that of benzene in soap micelles varies between 2.6 and 5.7. This is an important finding, since analyses of the benzene and toluene content of 27 widely different crude oils (*13*) showed that the ratio of toluene to benzene varied between 2.0 and 11.3 but that the average value was 4.6 ± 2.3, even though the absolute amount of benzene in these different oils varied by a factor of 600, from 0.00091 to 0.557 volume parts per hundred.

Similar analyses carried out by the U.S. Bureau of Mines (*14*) showed that in 21 domestic crude oils the average ratio of toluene to benzene was 4.1 and the average ratio in 11 foreign crude oils was 4.8.

To illustrate further the dependence of crude oil composition on the micellar solubilities of individual hydrocarbons, Eq. 1 has been used to predict the amounts of the very slightly soluble *n*-paraffin hydrocarbons that were isolated from one representative petroleum (*7*). A comparison of predicted and observed hydrocarbon abundances in API crude oil is shown in Table 1. The equation utilizes solubility data that were ob-

tained from dilute sodium laurate solutions. It may be noted that micellar solubilities of *n*-paraffin hydrocarbons decrease with increasing hydrocarbon size, just as the concentration of these hydrocarbons in crude oil decreases with increasing size.

Thus, the fact that the distribution of *n*-paraffin hydrocarbons in petroleum is different from that in sediments is easy to understand. If the composition of crude oil is determined primarily by hydrocarbon solubility in soap micelles, the distribution of hydrocarbons in oil need not bear any relationship to their distribution in the sediments. All the mechanism requires is that the sediments contain the necessary hydrocarbons in excess of the amount required to saturate the interstitial waters. Since hydrocarbons still are found widely scattered throughout ancient, highly compacted, nonreservoir rocks (*15*), an excess of sediment hydrocarbons over the amount which can be dissolved by the formation waters is clearly indicated.

Factors Which Affect Crude Oil Composition

If all crude oil deposits collected from ordinary water, one might logically expect them to have nearly the same composition; this, of course, they do not have. Although the distribution of individual homologs is similar from one oil to the next, crude oils do differ in the extent to which different classes of hydrocarbons occur—that is, there are paraffinic, naphthenic, and mixed-base crude oils, depending upon the type of hydrocarbons predominantly present.

Studies of hydrocarbon solubilities in dilute colloidal electrolyte solutions suggest that the variation in the composition of crude oils with respect to the predominant hydrocarbon type present may be due, in part, to variation in the types of colloidal electrolytes that were available to solubilize the sediment hydrocarbons.

In support of this viewpoint, studies of the solubility of normal paraffins and a naphthenic hydrocarbon in the micelles formed by sodium naphthenate show that the solubility of the paraffin hydrocarbons decreases with increasing size or molar volume, as one might expect (*16*). However, the micellar solubility, in a sodium naphthenate solution, of the naphthenic hydrocarbon 2-methyldecalin, which has almost the same volume as decane, is about 5 times greater

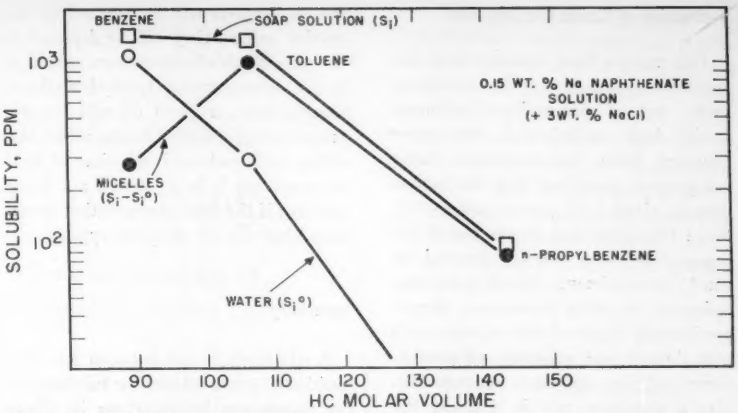

Fig. 2. Observed values for micellar solubility of single-ring aromatics, from which relative abundance of hydrocarbons in oil may be predicted.

than one would have predicted from considerations of size alone.

The data on micellar solubility are presented in Table 2. This table also shows that in sodium stearate micelles (a normal paraffinic soap containing 18 carbon atoms), the naphthenic hydrocarbon is no longer unusually soluble, but that octadecane, which has the same number of carbon atoms as the individual soap monomers, is about 16 times more soluble than one would have expected. If oil collected from waters containing sodium stearate as the main solubilizer, one might predict that the normal paraffin distribution curve of the unloaded oil would show a strong peak at carbon number 18. Such peaks between carbon numbers 16 and 18 have been observed in 12 oils that have been investigated in detail; these include samples from both the East Texas and the Big Horn basins (*17*).

It would seem, then, that colloidal electrolyte solutions show a greater solubilizing action toward hydrocarbons having the same general molecular structure as the soap molecules themselves, and hence that the presence of different natural solubilizers may account for the variation that is known to exist in crude oil types. Predominantly fatty acid salts might be expected to produce paraffinic oils, and naphthenic acid salts might be expected to produce naphthenic oils.

It is obvious, however, that variation in the types of natural solubilizers available is not the only factor that can influence the composition of crude oil. Our studies have shown, for example, that if sodium chloride is present in dilute fatty acid soap solutions, the solubility of paraffin hydrocarbons is markedly increased but that the solubility of the aromatic hydrocarbons is decreased. This suggests that crude oils collecting from saline waters will be relatively more paraffinic than oils collecting from fresh water. As a rule the older, more paraffinic, oils are associated with the more saline formation waters, whereas the younger, more cyclic, oils are associated with less saline waters. It should be kept in mind that the words *old* and *young* have to do only with the age of the reservoir rock in which the oil is now found.

Table 2. Selective solubilizing action of colloidal electrolyte solutions at 25°C.

Hydrocarbon	Molar vol. (ml/mole)	Micellar solubility*	
		Na naphthenate† (0.12 wt %)	Na stearate (0.15 wt %)
n-Decane	195	187	179
n-Octadecane	328	63.3	1008‡
n-Hexatriacontane	621	6.38	8.34
2-Methyldecalin	189	846	137

* $S_t - S_t^o$, expressed in volume parts per billion.
† Saturated with crude oil.
‡ The predicted value from a log ($S_t - S_t^o$) vol./vol. versus a molar volume plot is 64.0.

Formation of Crude Oil Deposits

Our studies have demonstrated that significant amounts of hydrocarbons can move out of fine-grained sediments, having been solubilized in the waters squeezed from the sediments during compaction, provided that the waters contain about 0.05 percent soap (*18*). Since the water that moves out of the compacting basin will be directed toward those sediments that offer the least resistance to water movement, disproportionately large volumes of water will pass through the sediments of greatest transmissibility, and these, consequently, play a dominant role in draining the compacting basin. Accordingly, large quantities of hydrocarbons, solubilized in soap solution, will be brought into particular beds (potential reservoir rocks) and given the opportunity to collect therein.

Although the mechanism by which the solubilized hydrocarbons come out of solution to form discrete oil droplets has not yet been determined, it is known that mere dilution of a soap solution will bring about the release of some of the solubilized hydrocarbons by destruction of the soap micelles. Such dilution would occur if meteoric water should enter the more permeable strata and mix with the water being expressed from the adjacent compacting sediments. While this is a reasonable mechanism, there are other factors, such as adsorption, salt concentration, and temperature, which may be involved in the unloading process. Once the oil droplets have formed in the more porous and permeable sandstones or limestones, they will continue to grow in size and, in response to the forces of buoyancy, will collect finally in the highest parts of the reservoir, where the oil saturation will increase significantly. The rate of final collection of dispersed oil droplets will depend upon the inclination of the reservoir strata; the greater the dip, the faster the rate of collection. During the time of final accumulation the oil droplets will be leached by the moving waters; they will be depleted in the more soluble hydrocarbons as well as in the accompanying nonhydrocarbons. Consequently, a given oil will become progressively enriched in the more paraffinic hydrocarbons if the time of final accumulation is long; it will not be so enriched if the final accumulation occurs soon after the oil droplets appear.

Summary

A relationship exists between the composition of crude oil and the solubility of the component hydrocarbons in dilute colloidal electrolyte solutions, suggesting that crude oil consists of hydrocarbons that were once solubilized in formation waters. It is not solubility in ordinary water or solubility in complete soap solution that correlates with the composition of oil but, rather, solubility in soap micelles. Because it implies a possible unloading mechanism, this concept is attractive, for it follows that when a soap solution is diluted with water, the soap micelles disperse and the hydrocarbons solubilized therein appear as discrete, filterable oil droplets.

Thus, it would seem that crude oil originates during the compaction of a sedimentary basin by virtue of the fact that sediment hydrocarbons dissolve in waters containing natural solubilizers and then come out of solution as oil droplets. The composition of crude oil as now understood is consistent with this hypothesis. And—most important—it is now possible to formulate meaningful questions, the answers to which, upon investigation in both field and laboratory, will go far toward enabling us to assess the validity of the mechanism presented here.

In addition to the implications regarding the composition of crude oil that are inherent in the hypothesis that crude oil collects from aqueous colloidal electrolyte solutions, there are several interesting implications from the geological viewpoint. To mention one, such a mechanism would lend credence to the suggestion that the source beds of petroleum are not necessarily unique accumulations of hydrocarbons in a limited area but, rather, may generally be coincident with the area from which water is expressed into the porous strata that eventually form the reservoirs.

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Resources, Population Growth, and Level of Living

A society's wealth depends on the use it makes of raw materials, energy, and especially ingenuity.

V. E. McKelvey

Most critical observers agree that the human race is currently facing the most crucial period in its entire history. The world population is exploding, for it is now more than 2.7 billion and is increasing at the rate of 45 million per year (*1*). If this rate of growth were to continue it would be only a few hundred years until there would be standing room only, and "a little after this the hypothetical human population would weigh more than the planet" (*2*). Even if population growth miraculously ceased now, known deposits of metals and fossil fuels of the quality currently mined would not sustain the present standard of living for more than a few scores of years. And, as if these problems were not enough, the major part of the civilized world is engaged in a debilitating cold war, the principal parties to which are equipped with weapons powerful enough to destroy the world's major cities in a matter of hours, and to make much of the rest of the world nearly uninhabitable in a matter of days or weeks. These problems are not insurmountable, but as Brown (*3*, p. 265) and others have emphasized, the rates at which the population is increasing, usable resources are being exhausted, and international relations are worsening are so rapid that we must act at once if we are to avoid catastrophe.

Effective action can be based only on an understanding of the interrelations of the basic factors controlling population growth and level of living (*4*), not only among scientists but also among political leaders, business men, and the public at large. Unfortunately, however, there seems to be so little agreement among the scientists that the general public cannot help but be confused (see *5*, pp. 241–262 and 285–287, and *6* for summaries of divergent views). Many believe, as Malthus did in 1798 and as Sir Charles Galton Darwin (*7*, *8*) does today, that the population will grow until food requirements outstrip supply; it will then be brought to equilibrium by famine or disaster. Others believe that advancing technology will make it possible to obtain raw materials and energy from sources that cannot now be exploited economically (*3*, *9*, *10*), so that shortages of natural resources will not curb population growth or depress the level of living, or at least will do so only in the very remote future. Some feel that since population growth appears to follow a logistic curve (*11*) that flattens as the population becomes literate and industrialized (*12*, *13*), world population will stabilize before the starvation level is reached. According to this view, "it is by no means certain that the maximum population will be determined by the food supply. It may well be that comfort and convenience will determine the limit" (*13*). And while some believe that population growth is likely to reduce the level of living (*14*), others believe that it has a beneficial effect on economic prosperity (*15*); that "in an advancing technology, more people mean more plenty" (*16*). Even war and preparation for war are sometimes regarded as beneficial economic stimulants (*17*).

Because the extremes of these views are nearly those expressed by Thomas Malthus and William Godwin at the start of the controversy 160 years ago, it seems safe to conclude either that little progress has been made since then in the understanding of basic principles or that new information is not widely understood. The latter explanation is the better, I believe, but in either case it is important that we make a strong effort to establish basic principles that can be applied to the solution of our problems. My purpose in this article is to try to improve understanding of the underlying principles both by examining theoretical relations and by analyzing observations on the relation of natural and human resources to population growth and level of living (*18*).

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Limitations on Growth of Populations of Simple Organisms

A spatially limited medium favorable to the existence of some simple organism could nourish only some finite number of individuals if the food supply were not replenished. The total number of individuals that could be supported in such a medium would vary directly with the initial size of the food supply, and inversely with the mean life-time food consumption of the individual. This situation, in which an unreplenished food supply sustains only a limited number of individuals, is usually observed only in the laboratory culture of such organisms as yeast, bacteria, fruit flies, and flour beetles (*19*; *12*, p. 31); but natural populations of certain insects are known to die because of having completely exhausted their food supply (*20*).

Most animal populations, however, are supported by a continually or periodically replenished food supply. The growth of a given population is limited not only by the size of the available food supply but also by disease, predators, or unfavorable extremes of temperature, salinity, moisture, or other physical or chemical variables in the environment. The maximum size such a population could attain would tend to increase as some function of the rate at which food generally becomes available and of the organism's comparative resistance to its physical and biologic enemies, and to decrease in some way with increasing mean rate of food consumption of the individual organism. It should be noted that while the organism may exert some ingenuity in searching for food, it is unable to increase the amount of food available in its environment.

Many observations of natural and laboratory populations show that when small numbers of a species are introduced into a bountiful environment, the rate of growth is slow at first but then increases rapidly (*12*). The maximum is reached in a surprisingly small number of gen-

erations. After this, the size of the population oscillates slightly with seasonal changes in food supply and environment, but it may fluctuate greatly and perhaps even decrease to zero if the food supply or the organisms' comparative resistance diminish sufficiently. Where food is the most critical factor, as it is likely to be, the size of the population is limited by competition for food among the individual members; many, particularly the young, are undernourished and do not live out their normal life spans.

Growth of Population and Level of Living in a Human Society

The limitations on the growth of populations of simple organisms are essentially those cited by Malthus as controlling the growth of human populations. Although he recognized that man can increase his own food supply, he believed that it can be increased only in "arithmetic ratio," whereas population tends to increase in "geometric ratio." Malthus also recognized that man might exercise "moral restraint" to limit the growth of his numbers. He largely discounted this possibility, however, and considered that growth of human populations is likely to be kept in check by undernourishment, disease, war, and disasters, and that because the population would always grow to the very limit of its subsistence, most of mankind would always be doomed to subsist at the minimum level.

Since Malthus' analysis and predictions were published, both the population and the level of living have risen to levels that he would not have dreamed possible (*3*, p. 5). Although his reasoning is thought to have been sound by some of his present-day supporters—who believe that the development of new lands, new resources, and new techniques merely postponed the fulfillment of Malthus' predictions—subsequent developments and further analysis of the principles involved show that he vastly oversimplified the relation man bears to his environment and underestimated man's ingenuity in developing and utilizing its resources. For example, because man not only seeks but, in all but the most primitive cultures, grows his food and makes his clothing and shelter, his essential needs include not only food but also tools and raw materials; and even in primitive societies he wants many more things than are necessary for mere subsistence (*21*, p. 86). He can satisfy both his needs and his wants only by exercising ingenuity, and his success in defending himself against his natural enemies is in large part a measure of his ingenuity. In addition, man helps satisfy his requirements by capturing nonfood energy for his own use, and—most important—his ingenuity permits him to satisfy his needs from new kinds of sources, many of which are more copious than the older ones.

Fairfield Osborn (*22*, p. 202) speaks of the "eternal equation" that controls the level of living and the growth of human population in various areas or societies, and he implies that this equation may be stated as follows:

$$\text{Level of living} = \frac{\text{resources of the earth}}{\text{number of people}}$$

This is a fuller concept of the relation man bears to his environment than Malthus had, because it recognizes that man, unlike simple organisms, makes direct use of many other things besides food, and that the consumption of goods and services is a variable in human populations analogous in importance to the number of people. But even this concept does not adequately represent the relation among the factors that control human life, for it implies that the "resources of the earth" constitute a fixed quantity that will yield a given output per capita.

A similar but less adequate concept is that of Vogt (*23*), in which population and level of living are determined mainly by the "carrying capacity" (C) of the land; this, he says, is equal to the ratio of the biotic potential (B) of the land to produce plants for shelter, clothing, and food and the environmental resistance or the limitations (E) that the environment places on the productive capacity of the land ("$C = B: E$"). Vogt recognizes that it is possible for man to alter the environmental resistance and hence to increase the carrying capacity, but the statement itself does not take into account the importance of other resources, nor does it give any direct indication that the carrying capacity of the land varies with ingenuity. The carrying capacity of the land, for example, for a food-gathering culture is several orders of magnitude less than it is for the modern science and machine culture. Both Osborn's and Vogt's concepts imply that the land will support no more than some optimum number of people, but, as Bauer and Yamey (*21*, p. 61) point out, "the most fundamental weakness of the concept of optimum population . . . is the underlying idea that, with given natural resources, output per head is a function of numbers alone. In fact, however, real income is vitally affected by the quality of the population, and the theoretical optimum would depend upon the skill, resourcefulness, and thriftiness of the population." As Kuznets (*21*, p. 129) put it, the major capital stock of an industrialized country is not its physical equipment; it is its body of knowledge and the capacity and training of the population to use its equipment effectively.

Although the factors that control human life are highly complex and in large part intangible, the fundamental ones, therefore, must include constructive technologic, socioeconomic, and political ingenuity—the collective ability of a group to obtain, distribute, and use raw materials and energy efficiently and to defend itself from its enemies, including disease and natural disaster. And instead of thinking of "resources of the earth" as a fundamental factor controlling the level of living and population at a given time, it is better to think of the net constructive rate of consumption and use of all types of raw materials, such as minerals, food, and water; and of the net constructive rate of consumption of all forms of energy, including a relatively small but essential amount of human energy as well as energy derived from other animate and inanimate sources. We can then say that the average level of living of an individual in a given society would tend to increase as some function of the net constructive rate of consumption or use of raw materials, energy, and ingenuity, and to decrease in some way with increase in the number of consumers.

This means that if the total consumption and use of raw materials, energy, and human ingenuity is at some fixed value (as it is in a given society at a given time), the level of living of the average individual decreases as the population increases; it also means that both population and level of living can be relatively high if consumption and use of raw materials, energy, or constructive ingenuity is also high. The expression does not tell us, however, what the potential maximum limit to the means of human subsistence is, nor does it tell whether or not population in a given society will come to equilibrium at a low or a high level of living.

These questions will be considered later, but before going on it is desirable to mention that the dependence of level of living and population on consumption of natural and human resources in the various countries of the world today is shown semiquantitatively by published statistics (see *5, 24*). For example, the per capita income in various countries correlates closely with the per capita consumption of steel and of energy obtained from commercial sources. A fair correlation exists also between per capita income and such things as literacy, percentage of students in secondary schools and colleges, per capita consumption of newsprint, and numbers of books published per capita. The correlation among these things is not exact because they are only partial measures of the controlling factors. Per capita income, for example, is a measure of level of living, but because it takes no account of materials already purchased and in use, it is only a partial measure of it. Steel is a key raw material, but it is only one of hundreds that are essential to industry, and again the annual production is merely suggestive of the amount in use. The consumption of energy is hard to evaluate, for published statistics exclude solar energy and energy from other noncommercial sources. And of course no statistic provides more than a feeble clue to the amount of ingenuity accumulated and in use.

Yet, in spite of the difficulty of measuring the controlling factors, the evidence is ample to show that level of living is generally a function of the per capita consumption and use of natural and human resources. Perhaps some optimum combination of raw materials, energy, and ingenuity is required to raise the level of living of the individual to the maximum, but it seems obvious that a large quantity of one will offset a shortage of the others, to some extent at least. Thus, it is due to "the skill and efficiency of the Swiss people that they have secured one of the highest standards of living in the world" despite their poverty in natural resources (*25*, p. 154).

Limitations on Growth of Population and Rise of Level of Living in Time

Is it possible to predict the potential population and level of living of a given area or of the world as a whole? This problem is far more complex than the one just considered. As a beginning, we could say that the potential level of living is an increasing function of the potential resources of raw materials, energy, and human ingenuity and a decreasing function of the potential population. This is not an adequate expression, however, for it does not take adequate account of additional complexities, such as the fact that some things, like war and population growth, that tend to decrease prosperity in the long run may tend to increase it for short periods because they create an expanding market and full employment. These stimulants are only of temporary value, however, and if they come at a time when they cannot be adequately supported by available resources they reduce the level of living and may even lead to disaster (*26*). With respect to ultimate world population growth, another factor not previously considered is man's requirement of a minimum amount of space in which to live. The amount of space required is not known, but whether it is an acre or a square yard need not concern us here; the point is that there is a minimum space requirement and that this would ultimately limit the earth's population if other factors did not.

The most important complication, however, is that man himself has demonstrated the ability to control every one of the variables (*27*, p. 18). He has not often deliberately fixed his standard of living at a low level, although he has done even this in certain religious societies, but in both primitive and advanced societies he has shown at times the willingness and ability to control population growth by one or another means of family limitation. And human history records an endless succession of discoveries that enabled man to utilize resources that were not utilizable before.

The discovery of fire, for example, made it possible for man to eat foods not edible before and to live in places not previously habitable. The discovery of agricultural methods made it possible for him to obtain many times as much food from a given area as the area yielded to the food gatherer, and the discovery of irrigation methods and of the use of fertilizers during earlier civilizations increased the yield many times more (*28*, p. 12; *3*, pp. 13–45). And the application of modern science and engineering to agriculture—the development of mechanized farm implements, fertilizers, insecticides, modern breeding practices, and so on—has increased the productivity of the land beyond anything imaginable even a half century ago. For the first users of copper, the only minable copper ore consisted of good-sized masses of native copper, but the discovery of smelting and similar technological advances made it possible to mine impure ores; the cut-off grade has dropped steadily until it is now about 0.4 percent in the large porphyry deposits. Aluminum, magnesium, and titanium were not even known to the ancients and were not thought to be valuable as structural materials even by the technologists of the early 20th century. Examples of discoveries that created *usable* resources where none existed before could be added indefinitely. Sociological, economic, and political discoveries, such as the invention of writing, money, and banking, the development of trade and of specialization in labor, and the development of systems of government that encouraged individual initiative, had a similar and perhaps even greater effect in making it possible to obtain more goods and services from a given area than had been possible before.

If it were possible, therefore, to write an equation showing the interrelations of potential population, potential level of living, and potential resources, the expression would show these variables to depend in some way on potential human ingenuity. It is unlikely, of course, that man will be able to control the other variables entirely, at least in the near future, but it is highly probably that even within short periods he will make new discoveries or acquire new knowledge that may alter his future completely. A recent and important example is the new look given the energy picture by the discovery of nuclear power. Prior to 1939, the world's energy supplies were thought to consist mainly of the fossil fuels—a few scores of years' supply in the form of petroleum and at most a few thousand years' supply in coal. No one considered that fissionable or fusionable elements might one day be a source of power, and the outlook for future supplies of power was dark. As recently as five years ago, well after the production of power by fission was known to be possible, Ayres and Scarlott (*29*), Darwin (*7*, p. 65), and others who did not have the benefit of the then classified data on results of postwar exploration for uranium, considered it likely that the energy derivable from nuclear power would not be any greater than that in the world's coal reserves, if as great. The energy in high-grade deposits of uranium

in Western countries alone, however, is now known to be several times that in all the fossil-fuel reserves combined; the amount in the uranium in black shales and phosphorites (which is being extracted in a few places now as a by-product of other operations) is at least ten and perhaps several hundred times larger (*30*), and that in granites and similar rocks is almost incalculable (*31*). And it now appears that enormous amounts of power will be available from thermonuclear fusion (*32*). Progress in mineral technology has also been impressive and may be expected to make available progressively lower grades and increasingly larger resources of minerals in the future, just as it has in the past (*10*).

This does not mean that William Godwin was right in his belief that natural resources, if used and distributed properly, would be adequate to support man's needs in spite of his reproductive proclivities; it does not mean that at any given time or even ultimately there will not be a limit to the resources-ingenuity product, or that at any given time or ultimately the population will not press closely on the means of its subsistence; and it certainly does not mean that something will turn up to solve all of man's problems whether he tries to solve them or not. It means, rather, that because man is potentially capable of controlling his numbers, his environment, his usable resources, and his very destiny to an *unimaginable* degree, it is not possible to predict the limit, temporary or ultimate, to his means of subsistence or his level of living (*33*).

Stimuli to Technologic Advance and Population Control

Although it is not practical to make long-range forecasts of growth of population or rise or fall of the level of living, it is of utmost importance to learn the circumstances under which man uses his fabulous capacity to increase the means of his subsistence and to control his numbers. Doubtless modern behavioral science can cast much light on these questions, but for the purpose here it suffices to approach them by analyzing present and previous patterns of population and economic growth. The rate of population growth differs considerably in different parts of the world now, and it probably always has. For example, the world population is at present more than 2.7 billion and it is increasing at the rate of about 1.7 percent per year (*1*); but the population of northern Europe is increasing at the rate of only about 0.6 percent per year, while that of Canada and Australia is increasing at the rate of 2.4 percent and that of certain underdeveloped areas like Mexico is increasing at rates of more than 3 percent (*26*). The current average rate of population growth has prevailed for only about two decades; the largest growth has taken place since about 1650. The world population is thought to have been about 0.2 billion at the beginning of the Christian era, and by 1650 it had grown to not much more than 0.5 billion (*5*, p. 33). It took about 200 years to double that figure and less than 100 years to double it again. The distribution of the relative increase was extremely irregular: From 1650 to 1950 the population of Africa doubled; that of Asia increased 3.8 times; Europe, 5.6 times; that of Central and South America, 13.5 times; and that of America, 166 times. The largest absolute increase in number of people, however, took place in Asia, whose population in 1950 was about 1.3 billion.

Populations of Western Europe

Although the population growth of recent centuries has been unequally distributed, it shows in the aggregate a rapid increase. In most of the Western European populations, where the increase took place first, this rapid increase has been followed by a decrease in rate of growth. The curve representing their growth since about 1700 is the *S*-shaped logistic curve similar to that found in the growth of animal populations (*12*, pp. 11–18); the growth it reflects has been called the population cycle, which is broken into four stages, as follows (*25*, p. 9): (i) the high-fluctuation stage, characterized by high birth and death rates and by a very slow, irregular increase in population; (ii) the early-expansion stage, characterized by a high birth rate and a falling death rate; (iii) the late-expansion stage, characterized by a falling birth rate as well as a falling death rate; and (iv) the low-fluctuation stage, characterized by a low death rate and a low birth rate, oscillating slightly with booms, depressions, and wars. Transition from one to another of these stages represents the effect of a change in the ratio of births to deaths, and perhaps also of changes in direction and amount of migration. But what are the fundamental causes of these changes?

The high-fluctuation stage in the history of the Western Europeans seems to have been one in which population was pretty much in equilibrium with food production. Population increased in time of plenty and declined sharply when famine or pestilence raised the death rate; in the meantime substantial growth was prevented by a high death rate that was the direct or indirect product of undernourishment among a large segment of the population. The early-expansion stage, which began during the 17th century, was due "in part to gradually improving agricultural techniques, but probably in greater degree to better transportation, which in turn stimulated commerce and handicraft production, and, through these, commercial agriculture," both in Europe and in new lands settled or dominated by Europeans (*13*). This tended to reduce famine, undernourishment, and susceptibility to disease, and hence led to a decline in the death rate. Even though this early growth was not stimulated by much increase in the use of fossil fuel and steel, it was made possible, nevertheless, by increased availability and use of raw materials, energy, and ingenuity, all of which expanded the supply of food and other necessities.

The late-expansion stage of the population growth of Western peoples is closely tied to the industrial or scientific revolution. Thus, Hubbert (*34*) has shown that the population growth of the last 150 years, the largest in human history, is closely correlated with the greatly increased use of energy from fossil fuels; the latter is directly paralleled by increased consumption of metals and many other raw materials. Mere production figures, however, do not adequately describe the intellectual explosion that permitted man not only to prolong life by the conquest of disease (*35*, p. 7) but also to discover and utilize natural treasures whose very existence was previously unknown. The vastly increased amount of goods, services, and knowledge available for man's use performed "the western miracle" of simultaneously increasing population and raising the level of living (*22*, p. 75).

The low-fluctuation stage is a recent development, reached in western European countries only within the last century. It is characterized not only by a relatively stable population but also by a rise in the level of living—an enigma from the standpoint of Malthusian doctrine. The causes for the decline in birth rate are complex, but three things seem

especially significant: (i) Recent studies of birth rates among various socioeconomic groups show that group differences are mainly due to the differential prevalence of birth-control practices (*36*); (ii) the net reproduction rate among families within individual countries or areas generally varies inversely with family income and degree of educational attainment (*12*, p. 158; *37*; *5*, p. 156); and (iii) over the world as a whole, areas that have the highest birth rates are those in which the highest proportion of the population is illiterate and dependent on agriculture (*13*; *27*, p. 50). These observations indicate that in relatively well educated and wealthy nations and social groups, the birth rate drops because married couples *want* to have fewer children, presumably because they want to attain or maintain a higher level of living for themselves and their children, or because they do not "wish to bear the physical and social burdens which a large family brings" (*38*). The birth rate remains high among low-income and poorly educated groups because their outlets for nervous and emotional tension are restricted (*12*, p. 203; *35*, p. 296), they are not educated in the art of contraception, they are not able to afford contraceptive devices, and they are not well informed as to the consequences of having a large family.

It is important to note that the drop in birth rate in Western countries has taken place in spite of strong opposition to family limitation. In Ireland, where both the Catholic Church and the state have encouraged large families, the population decreased from about 8.2 million in 1845 to about 4.4 million in 1950 (*35*, pp. 53, 92). Death and emigration reduced the population by about two million during the potato famine years of 1847–1852, but the remainder of the reduction results from a low birth rate due to few and late marriages.

Until recently it was thought that after a particular nation once reached the low-fluctuation stage of the population cycle its population would be stable, or at least its further growth would be slow. In the United States, Canada, and Australasian countries, however, it has been found that under certain circumstances population stability or slow growth is merely temporary. In the United States the birth rate declined rather steadily during the first third of the 20th century, reaching a low of about 19 per thousand per year during the 1930's (*39*), but in 1940 it started to rise, and since 1951 it has been about 25 per thousand. The reversal in the trend of the birth rate is generally thought to be related to increased payrolls and employment resulting from the defense and war efforts, but the high postwar birth rate is puzzling (*25*; *40*, p. 46). At first glance it does not appear to be caused by national prosperity, for per capita income rose in the early part of the century while the birth rate declined. But inasmuch as the size of the family in the United States is now largely a result of a decision made by the parents, it seems likely that the increased birth rate in the United States reflects a recognition on the part of our young people that their potential income does not require them to restrict the size of their families closely in order to realize their wants and fulfill their responsibilities adequately. The wish to avoid the physical and social burdens of a large family may still militate against large families, but the leisure afforded by a shorter work week and by labor-saving devices, such as the dishwasher and automatic washing machine, makes it possible to have a medium-sized family without having as burdensome or complex a life as the same responsibilities would have entailed in the 1920's. It seems safe to conclude that a rise in national prosperity may stimulate population growth in late as well as early stages of industrial development.

Population Cycle in Earlier Epochs

The main aspects of this population cycle or growth curve appear to have been repeated during each of the successive cultural epochs in the history of mankind (*12*, p. 19) and during each of the earlier civilizations. Clough (*28*), in his analysis of the factors controlling the rise and fall of civilizations, finds that all civilizations were marked by, and to a large extent caused by, an increased output per capita of goods and services and the accumulation of an economic surplus. This permitted both an increase in population and a rise in the level of living, and it also provided time for intellectual and esthetic achievements—the hallmarks of civilization. The increased output resulted from improvements in technology, greater exploitation of natural resources, increased efficiency of labor resulting from specialization, accumulation of capital, increased business enterprise and leadership, improved techniques of distribution, and development of an economic and political system that not only encouraged individual and group enterprise but also permitted wide enough distribution of wealth to enable the laborer to be a heavy consumer of goods and services. When the population reached a size at which existing techniques, resources, capital, trade, and political organization were unable to provide a further increase in goods and services per capita, population growth tapered off and the level of living gradually declined. If for any reason the political and economic framework of the civilization deteriorated, population actually decreased and entered the high-fluctuation stage. Later, when political or technologic conditions once again favored the accumulation of an economic surplus, a new cycle of growth sometimes began, either in the same area or, more commonly, in adjacent areas.

In contrast to the causes of decline in the rate of growth of western European populations—family limitation stimulated by desire for a higher level of living and a less complex life—the decline in growth of population of most earlier societies was due mainly to the positive checks cited by Malthus. A great variety of methods of family limitation, ranging from abortion and infanticide to various sexual taboos and marriage bans, were practiced in early societies; when practiced extensively they helped make it possible to avoid widespread starvation, but they do not seem to have been effective in maintaining a high standard of living.

Why did earlier civilizations rise and decline? What stimulated and then depressed technologic, economic, social, and esthetic progress? Toynbee (*41*, p. 570) explains that civilization arises "not as a result of superior biological endowment or geographical environment but as a response to a challenge in a situation of special difficulty which rouses him [man] to make a hitherto unprecedented effort." He lists a number of adversities that provide the necessary initial challenge—hard country, new ground, defeat in war, threat of war, and penalization imposed by reason of race, religion, or class; further growth, he thinks, results from "an overcoming of material obstacles which releases the energies of the society to make responses to challenges which henceforth are internal rather than external, spiritual rather than material." Though granting that necessity is often the mother of invention, I believe that the growth of civilizations must have been stimulated by more than this, for many more peoples have been exposed to adversity and spiritual challenges than

have made the grand response that the development of a civilization demands.

Clough (*28*, p. 9) supplies the missing link in emphasizing the importance of the ideologies of a culture, which generally become established at its very beginning. If in its formative stage "the culture embraces the idea that great works of art should be created, that knowledge of the universe should be acquired, and that man should extend his control over human and physical environment, then subsequently more of the energies of the culture will be devoted to the attainment of a high degree of civilization than would otherwise be the case. . . . Another ideology which is important for the effective development of civilization is a desire for a social and political organization which will permit individuals to realize their total potential as contributors to civilization." He stresses also the importance of avoiding destructive strife, of placing leadership in the hands of those who would advance civilization rather than some other cause, of preventing such a rigid structuring of the culture that the individual has no choice of action, and of increasing "the range of opportunities for alternative decisions. . . . Everything which contributes to the extension of that range, whether it be economic surplus, the use of leisure, the development of cities, or the absence of stultifying rigidities, is of the utmost significance in furthering the process of civilization."

Whereas the rise of earlier civilizations was marked by a gain in control over both the physical and human environments, their decline reflected a reversal of these trends. Specific causes may have been disappearance of economic surplus, resulting from population growth, exhaustion of natural resources, war, or diversion of capital from productive investments to nonproductive expenditures on costly works of art (for example, the Pyramids) or luxurious living (*28*, p. 261); enemy conquest, the success of which may be the result of the diffusion of the fallen civilization's techniques to bordering peoples; disease or pestilence; social and political disorders, leading to debilitating internal strife; deterioration of leadership or government; or loss of creativity as a consequence of a stultifying religion, tradition, or social order (*41*, p. 581). The relative importance of these causes is hard to assess. Population growth outstripped the production of food and other necessities in the homeland in some and perhaps in all of the earlier civilizations, so that they became dependent on trade and conquest to maintain their level of living (*3*, p. 24–30). Yet nearly all of these areas are now supporting more people at a higher level of living; obviously, then, they did not exhaust their resources but merely reached the production ceiling permitted by their technology and their economic and sociopolitical systems. It seems likely that even without further technologic advance they could have avoided or postponed decline if they could have dealt with subjugated peoples, competitors, and envious barbarians by means more effective and less expensive than military force, and if they could have prevented or satisfactorily dissolved internal social disorders. Failure to maintain or extend control over the human environment, to organize their "society in such a way that differences among individuals and groups may be at a minimum and that what conflicts do exist may be settled in an equitable manner according to previously established rules," and to place sufficient value on human life and freedom (*28*, p. 260) seems to have been at the root of the decline.

Populations of Underdeveloped Countries

If judged wholly by their rapid rate of increase, the populations of many of the underdeveloped countries today would appear to be in the early expanding stage of the population cycle. Unlike the Western countries and earlier civilizations, however, the underdeveloped countries began their recent growth not because they opened new geographic, technologic, or economic frontiers but because Western countries introduced better methods of transportation, communication, agriculture, and—most important—medicine and sanitation (*35*; *3*, pp. 57–58). Deposits of minerals and fuels have been developed in these countries, to be sure, but because these have been largely exported to Western countries they have not done much to raise the level of living of the native populace, which has remained dominantly agricultural. The result of all this is that death rates have been reduced, the populations have grown, and in some countries the amount of food and goods available per person has diminished (*42*; *40*, p. 48). No significant rise in level of education, which might check population growth as it has in Western countries, has taken place in most of the underdeveloped countries, and population growth seems to follow a strictly Malthusian pattern.

Summary of Basic Relations

This brief analysis of the relations of population growth and level of living to natural and human resources yields several relatively simple but important principles, as follows. The means for man's subsistence increase with increasing constructive consumption of raw materials and energy and, especially, constructive use of ingenuity. Resources of usable raw materials and energy may be increased to an unpredictable extent by the development and application of ingenuity. The most fundamental stimulus to ingenuity is a basic ideology that challenges, encourages, and rewards individual initiative, freedom of thought, desire for economic gain, and thirst for knowledge. The attainment of a high standard of living requires that the ratio of consumption to consumers be high. Such a ratio can be maintained most easily if the population is sufficiently educated to understand the benefits and the means of family limitation and to extend its control over its physical and human environments by peaceful means.

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Francisco Duran-Reynals was born in Barcelona, Spain, on 5 December 1899. He died in New Haven, Connecticut, on 27 March 1958.

His early education, from elementary school through college, was in Barcelona. There too he took his M.D. degree in 1925. In the course of his medical study he was also assistant in the laboratory of bacteriology of the city of Barcelona. On his graduation he became a fellow of the "Junta para ampliación de Estudios." The first year of his fellowship, 1925–26, he spent at the Pasteur Institute in Paris. In 1926, still under the fellowship, he came to James B. Murphy's laboratory in the department of cancer research at the Rockefeller Institute in New York. In 1928, when his fellowship ended, he was appointed an assistant in that department, and in 1934, an associate.

In 1938, Duran-Reynals left the Rockefeller Institute to accept an appointment as research professor at Yale University School of Medicine, under the Jane Coffin Childs Memorial Fund for Medical Research. He was also appointed lecturer and research associate at Yale in 1952.

He was a member of the Academia de Medicina and of the Sociedad de Biologia of Barcelona and a corresponding member of the Institut d'Estudis Catalans and of the Sociedad de Biologia of Havana. He was also a member of the Harvey Society, the American Association for Cancer Research, and many other societies. He was for many years a scientific associate of the Jackson Memorial Laboratory in Bar Harbor, Maine, and spent many summers there. In 1957 he received the honorary degree of Doctor of Science from the Hahnemann Medical College of Philadelphia. He held medals from the Pasteur Institute and from universities of Liège, Brussels, and Montreal. In 1952 he received the Anna Fuller Memorial Prize for medical research. He was a consultant to the U.S. Public Health Service, the National Research Council, and the American Cancer Society.

During his stay at the Pasteur Institute, Duran-Reynals' work had dealt primarily with the lysis of certain bacteria, but soon after coming to the United States he began to take an active interest in viruses. This interest deepened and widened. At the same time the influence of testicular extract as a "spreading factor" was noted and was used fruitfully to study cell physiology (the ground substances of the mesenchyme). The two lines of research seized his imagination, and he held to both of them eagerly and vigorously.

His studies of the ground substances showed them to be a system of fundamental importance influencing the rate or success of infection, metabolic changes in cells, stability of crystalloids, intimate effects of hormones, allergy, and other phenomena.

Through investigation of a variety of known cancer viruses, notably avian, Duran-Reynals established a number of important facts concerning the nature and activity of those agents. Among these principles may be listed the following: (i) These agents can exert necrotizing effects on cells under certain conditions, notably in the young host. (ii) They can vary, adapting themselves to new hosts. When an "adaptation" occurs, a different type of cancer is induced. Thus, a single virus may be involved in the induction of many types of cancer. (iii) They have definite antigenic properties. (iv) They have their highest power of infection when injected in young hosts. (v) They have a definite epidemiological pattern.

From this work Duran-Reynals concluded that "cancer viruses" behaved fundamentally like other viruses and that possibly cancer could be considered to be of viral origin. For the sympathetic consideration of this hypothesis he was a willing and tireless crusader.

These conclusions led to the development of the second phase of his program in this field of research. This consisted in trying to discover whether ordinary viruses, especially those of the pox group, could, under certain conditions, induce cancer. Interesting and suggestive results were obtained, but the problem was unsolved and he was hard at work on it when his final illness set in.

He was an extremely versatile and imaginative investigator. His bibliography attests strikingly to this fact. Throughout his activity as a brilliant research worker he was strengthened and encouraged by the complete partnership and active as-

sistance of his devoted wife, Maria Louisa Maristany, whom he married in 1936. They have one child, a daughter, Francisca, now a student at Bryn Mawr.

To Francisco Duran-Reynals, life was an art and a high adventure. He felt disappointments keenly, but they could never, in the face of his unyielding purpose and conviction, lead to discouragement. To an extraordinary degree he was able, by contact, to transfer to others the intellectual vitality and enthusiasm which he possessed or—perhaps better—which possessed such a large part of him. He did this naturally and with complete simplicity.

Sensing inwardly the drama of the search for and discovery of new scientific knowledge, he reflected his own absorption and emotion in the presentation of the results of his research work. One had the overpowering feeling that, as a part of the audience, he was reliving the collection, tabulation, and interpretation of the experimental results. They entered the hearer's consciousness as living, meaningful units of scientific progress, not as dead and recorded facts.

The experience of presenting his results was so vivid and intense to Duran-Reynals that it was at times almost exhausting to this sensitive and completely consecrated man. He would fret and chafe at the unavoidable waiting and slow unfolding of a scientific program. One could see that his keen, alert mind was "champing at the bit" to be at the job of exposition and discussion.

There were many times when his handsome aquiline profile and proud searching eyes reminded one strongly of a poised hawk ready to wheel and strike, but only to *capture,* not to *kill.* For there were few if any destructive elements in his character. He was absorbed in the joy of the hunt—the finding of the unexpected—and not in tearing to pieces the work of others. He expected the good and the true.

Duran-Reynals had a great capacity for kindness, affection, and loyalty towards others. These qualities made a powerful and invulnerable framework for his life. In the years that I knew him he never aged or wavered in the spiritual integrity of his deep faith in mankind and in God. In fact, he had richened and ripened in that faith to a point that made one realize that he had atttained the rare inner peace that is built of unselfish action, devotion to work and to ideals, and unstinted giving of oneself.

His life proved that high standards of scientific research and complete humility of spirit can be symbiotic in the truest sense of that term. It proved also that their combination can give a fine and beautiful light which is a source of encouragement, inspiration, and thankfulness to others. The tragedy of Duran-Reynals' early death and of the suffering which preceded it are softened gently and beautifully by the ageless, simple qualities of human greatness of which his life was composed.

C. C. Little
Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine

News of Science

Greater Role for U.N. Specialized Agencies Seen in Meeting Problem of Population Outrunning Resources

In recent years the United Nations has played an important part in studying, through demographic surveys, the unprecedented growth in world population. But now there is a growing feeling that the U.N. should assume an active role in promoting population control. Since the beginning of this century, the population has increased more rapidly than ever before in history, chiefly because of scientific advances that have led to progressively lower mortality rates, while birth rates have not declined. A few figures from a recent report, *The Future Growth of World Population,* published by the U.N. Bureau of Social Affairs, bring the situation into focus.

Population Growth

During the first half of the 19th century, world population reached 1 billion; in 1930 the figure was about 2 billion. In 1957 and 1958 alone, the earth's population increased by 90 million, a figure twice the population of France, and the world is expected to have 3 billion inhabitants by 1962.

The acceleration of population growth in underdeveloped countries is especially spectacular. Annual increases of 2 percent or more are usual in most of these countries, and in some there is a growth of 3 percent, a rate that the U.N. report describes as "probably outside the experience of any nation before the last ten-year period." In contrast, the population of the United States is growing at the rate of 1.7 percent per year.

Japan is the only country that has had a sharp drop in birth rate. Within the last decade its birth rate has been cut in half: from 34.3 per thousand in 1947 to 17.2 in 1957. (Three quarters of the reduction was caused by induced abortion, according to *News of Population and Birth Control* for December 1958, published by the International Planned Parenthood Federation).

Today, Latin America has the most rapid population growth of any major area. If the trend continues, by the end of the century it will have the second largest population, 593 million, among the world's major regions. Asia, with a projected 3.9 billion people, would remain in first place.

United Nations Action Impeded

The March issue of the Population Reference Bureau's *Population Bulletin,* which reviews world population, pays tribute to the invaluable work of the United Nations in the field of demography, but in a section headed "An Agonizing Appraisal," it points out that the U.N. has been "impeded in any realistic, curative attack on the population problem, because of a three-way split in thinking concerning policy formulation." The three factions are the Communist bloc, the Roman Catholic bloc, and the Western bloc.

According to observers, the Communist bloc maintains that to limit population is to limit the growth of the masses, the working people. The Communist group acknowledges the population problem but feels that with a changed economic and social order, living standards could be improved to meet the rapid population increase. An example of the Soviet stand was provided

on 13 March at a meeting in Australia of the U.N. Economic Commission for Asia and the Far East. During a 2-day debate on population the Soviet delegation was the only one to oppose limitation of the fast-growing Asian population. P. M. Chernyshev, deputy leader of the delegation, is reported to have said (*New York Times*, 15 March): "The key to progress does not lie in a limitation of population through artificial reduction of the birth rate, but in the speedy defeat of the economic backwardness of these countries."

It is interesting to note that Kerala, the only Communist state in India, has perhaps one of the most advanced birth-control programs in the country. An Indian spokesman reports that at first the Communist politicians opposed the Central Government's family-planning program, but when they came to power they reversed their stand because they found it impossible to deal with Kerala's economic difficulties without reducing the dense population—1017 people per square mile.

The U.N.'s Roman Catholic bloc concedes that rapid growth in over-populated regions is serious; however, it refuses to consider any corrective programs that might lead to the use of controls morally unacceptable to the church. The third group consists of the demographic representatives of the Western nations, who cannot accomplish very much without the cooperation of the first two groups.

The Population Reference Bureau article observes that the result of these differences has been a "tendency to talk in generalities, and to shy away from recommendations for coordination of United Nations efforts and for guidance to member nations in policy formation." The article ends by pointing out that the global efforts to reduce mortality cost approximately $30 million each year, while only a few million dollars are allocated to programs that affect birth rates.

U.N. Population Commission Meeting

A recent major event in population study, the biennial meeting of the United Nations Population Commission, provides encouragement about the future role of the U.N. At the close of a 2-week session in Geneva, the commission adopted unanimously a report that called attention to the "unprecedented increase" in world population. The 15-member body expressed concern not with the accelerating growth itself but with its social and economic consequences in underdeveloped countries. The commission urged that the United Nations shift the emphasis of its activities in the demographic field, saying: "While continuing to increase the technical coverage and quality of demographic information, it can devote more attention to aiding countries in the study of the interrelation of population growth, vital rates and population structure on the one hand, with economic and social development on the other."

Since the United Nations population efforts have so far been primarily devoted to collecting data, the recommendations approved by this conference indicate a distinctly hopeful trend. Robert C. Cooke, director of the Population Reference Bureau, commented that this formal recognition of the soaring population, combined with the suggestion that data be related to economic and social problems, could be described as a "notable milestone" in United Nations population activities.

The report of the Population Commission, a subsidiary body of the U.N. Economic and Social Council, will be presented to the council's 27th session, convening in Mexico City on 7 April.

Illiteracy Rates Cited

Last month some of the key factors in population study were outlined by William S. Vogt, director of the Planned Parenthood Federation of America, when he spoke in Washington on "Population Growth and Dwindling Resources." In analyzing the interrelationship of population and various economic and social factors, Vogt stressed the kinship of population and literacy rates. Without education, economic improvement is impossible. In Egypt the illiteracy rate dropped from 93 percent to 80 percent in a 40-year period, but the number of illiterates increased by 3 million. In Brazil the rate dropped from 65 percent to 51 percent between 1900 and 1950, but the number of illiterates increased by 9 million. And finally, in India the rate dropped from 94 percent to 80 percent, but the number of illiterates increased by 138 million.

Vogt then presented some figures from the point of view of our educational statistics at the primary-school level. Our annual population is increasing at the rate of 11 percent in the number of children in the primary grades. In Egypt the number is 33 percent; in El Salvador, 35 percent; in Mexico, 27 percent; and in Taiwan, even with the West's extensive aid, 29 percent.

Vogt emphasized that in all the underdeveloped areas there is great mismanagement of resources; soil erosion is acute. He commented that India, in particular, with its annual population increase of 6 to 7 million, is a challenge to science. India will double her population of some 370 million in 40 years, Pakistan in 35. In northwestern India the soil is so exhausted that it contains only 1 percent organic matter. Vogt mentioned the recent food riots and the United States wheat that is being sent to prevent famine.

Planned Parenthood Conference

Vogt devoted much of his talk to Southeast Asia, basing many of his remarks on two papers that he had heard at the International Conference on Planned Parenthood in New Delhi, India, 14–21 February. One of the papers was by Halvor Gille, a Dane who is social affairs officer for the Social Affairs Division of the U.N. Economic Commission for Asia and the Far East. Gille did not attend the Delhi meeting in an official capacity, however. When Vogt explained this, he mentioned the inadequacy of the United Nations program.

Gille's paper pointed out that although Southeast Asia covers only one-seventh of the total land area in the world, it has 53 percent of the world's population. He emphasized that the region has more than 25 million new mouths to feed every year, and that per-capita food consumption is 15 percent below the prewar level, despite all the scientific and agricultural efforts. He estimated that in mainland China alone, with 650 million people, the population is increasing by more than 1 million every month. Vogt said that another of Gille's interesting points was his observation that children under 15 years of age constitute about 40 percent of the population in the region, whereas they constitute only 25 percent in the West.

The second paper that Vogt described was "Population in an Atomic Age" by Homi J. Bhabha, chairman of the Indian Atomic Energy Commission. Bhabha has no faith that population can be reduced through clinical methods, certainly not those of the West. Pointing out that to improve living conditions in India an immediate 30-percent population reduction is necessary, Bhabha suggested that the only solution is an oral contraceptive that could be put into food—into rice or salt, perhaps. Further, he urged the creation of a "strong" central institute for research into the problem of controlling population on a national scale. Observing that Bhabha's paper had been most impressive, most forthright, Vogt said: "If we could get more Asian scientists such as Bhabha working on this problem, I'd be a lot more optimistic."

Sir Julian Huxley, eminent British scientist, also spoke at the conference on the subject of oral contraceptives, saying, according to the *Hindustan Times*:

"Efficient birth control methods are necessary to counterbalance the effect of efficient death control. Research for the development of a cheap and satisfactory oral contraceptive should be international."

On the final day of the New Delhi meeting, the role of the United Nations was again emphasized when the conference adopted a resolution which proposed that a family-planning program

be made an integral part of the activities of United Nations specialized agencies. The resolution made these recommendations: (i) the World Health Organization should provide contraceptive information as a part of its health program; (ii) the Food and Agriculture Organization should combine a family-limitation campaign with its efforts to increase food production; (iii) the Economic and Social Council should consider family planning as a "major means" of improving living standards; and (iv) the Human Rights Commission should include voluntary parenthood and freedom to obtain family-planning education in the listing of basic human rights.

Fallout of Strontium-90

On 23 March new information about fallout of radioactive material from nuclear tests was released in censored form by Senator Clinton P. Anderson (D-N.M.), chairman of the Joint Congressional Committee on Atomic Energy. The information appeared in part in letters by Maj. Gen. Herbert B. Loper (retired), special atomic energy assistant to the Secretary of Defense, and Willard F. Libby, commissioner, Atomic Energy Commission. Following are the texts of the letters.

Letter from Loper

Feb. 19, 1959

DEAR MR. CHAIRMAN:

The following is a brief status report outlining the present programs for analyzing and evaluating the radiation hazards resulting from atomic detonations.

Fallout reports from Operations Redwing (1956), Plumbbob (1957), and Hardtack (1958), are currently under preparation.

The hazards of local contamination from nuclear-weapon detonations have been fairly well delineated. However, the difficulty in accurately predicting the rapidly varying atmospheric conditions results in uncertainties as to the area of fallout. Predictions of local fallout contours from enemy bombs must be based on a large number of assumptions such as the type of weapon, height of burst, and yield. These unknowns do not allow accurate prediction of fallout from enemy bursts during wartime. Delineation of contaminated areas by airborne radiac instruments after deposition of the fallout is presently practicable and will be of considerable military and civil value during wartime.

The deposition of world-wide fallout or world-wide surface contamination is now beginning to be accurately measured . . . (Classified portion deleted) . . . Recent indications are that the radioactivity in the stratosphere has a residence half-life of two years (in contrast to the previously assumed value of about seven years) and the present amount of Sr^{90} in the stratosphere would be maintained by the injection of about 6 megatons of fission products per year. The concentration of the Sr^{90} on the surface of the earth is greater in the United States than in any other area of the world. The danger of carbon-14 and cesium-137 has been examined, and the immediate probability of any one individual being affected is about 1 in 500,000.

The risk of damage resulting from the testing of weapons is therefore extremely small and much less than other common occurrences such as x-rays, automobiles, chemical contaminants, household cleaners, etc. However, the probable casualties attributable to radioisotopes from weapon testing when summed over the populations of thousands of years create a moral issue that could be of considerable propaganda importance.

The distribution of the radioactive debris in the stratosphere as a result of the detonations to date is not clearly defined as to its altitude and latitude variation. The altitude dependence partially determines the drip-out rate and the latitude dependence influences the extent to which the world-wide fallout is uniform over the earth. Tentative conclusions to date indicate that three-tenths of the quantity of radioactive debris leaves the stratosphere each year, that the north-south diffusion of radioactive particles in the stratosphere does exist, and that in both hemispheres there is a latitude band of maximum drip-out which is from 35 degrees to 50 degrees north or south.

There is a need for more experimental and collecting programs in the following areas of the effects and behavior of fallout from nuclear weapons:

(a) Amount of fallout deposited locally from a low height of burst.

(b) More accurate determination of the drip-out rate of radioactive particles from the stratosphere.

(c) Further define the estimate of the amount of radioactivity formed per kt [kiloton] of fission yield.

(d) The refinement of measuring techniques to account for all radioactivity produced from a nuclear yield.

(e) Advancements in the knowledge of fireball chemistry, physics and particle behavior.

(f) Response of biological systems to radiation.

Sincerely yours,

(s) HERBERT B. LOPER

Assistant to the Secretary of Defense (Atomic Energy)

HON. CLINTON P. ANDERSON

Chairman, Joint Committee on Atomic Energy

Letter from Libby

Feb. 27, 1959

Hon. Herbert B. Loper, Chairman,
Military Liaison Committee.

DEAR GENERAL LOPER:

In connection with your letter to Senator Anderson of Feb. 19, 1959, concerning radiation hazards resulting from atomic detonations, I have just completed a study of data . . . which you kindly made available to us last December. I am sorry that, because of the complexity of the problem and my preoccupation with other duties, I have been so slow in finishing my consideration of the data and in sending on my comments. . . .

I think your letter to Senator Anderson is an excellent exposition of the present position we are in. There are, however, one or two points you make on which I believe further words are necessary in order to resolve some questions.

The extensive data that have already been published by Project Sunshine and the United Kingdom study group, together with your beautiful . . . work, still leave us, despite their great volume and complexity, in some uncertainty, as you say, as to the distribution of the radioactive debris in the stratosphere to both altitude and latitude variation, since the altitude variation determines in part the drip-out rate and thus the residence half-life in the stratosphere, this quantity is left in some doubt. My own present conclusion is in agreement with yours as stated in your letter, in that my previous value of seven years for this important number is too long and that it should be reduced. In a restudy of this question being released March 13 in Seattle, a copy of which will be sent you as soon as it is printed, a new value of about four years rather than the earlier seven is arrived at. I find it difficult to push it down to the two years you give as an indicative value.

On the amount of strontium-90 in the stratosphere, at the present time there is a somewhat larger difference in our estimates which may be due to your not having included the Russian series of last October, which in itself alone, according to my estimates, increased the stratospheric inventory by about 50 percent. . . . You give the present inventory as requiring 6 mt (megatons fission equivalent) per year to be maintained at its present level. For a half-life of two years this corresponds to only 17 mt total and appears to leave too little room for the injections from tests before last October, which I estimate still have left some 25 to 30 mt and a corresponding required rate of injection for steady maintenance of about 7 mt per year. The closeness of this figure to your 6 mt per year number shows how badly we need further information on the actual stratospheric content.

You indicate that the stratospheric fallout occurs at maximum rates in the 30 degree to 50 degree bands of latitude in both hemispheres. This old argument still is not quite settled, I believe, although the evidence in favor of your conclusion is increasing. My principal difficulties with it at the moment are that we know that a considerable part of the peak in observed fallout in these latitudes in the Northern Hemisphere is due to tropospheric or local fallout which was never in the stratosphere and the evidence for a corresponding peak in the Southern Hemisphere seems to be rather weak.

With respect to the carbon-14 and cesium-137 hazards, the laboratories measuring radiocarbon dates in various parts of this country, in Europe and New Zealand have sent me data on the present increase in the carbon-14 content of living matter which amounts to about 10 percent of the natural level of carbon-14 from the cosmic rays which in itself corresponds to about 1.5 milliroentgen per year—about 1.5 percent of the average total natural dose rate. Turning to cesium-137, Dr. E. C. Anderson in the Health Division at our Los Alamos Laboratory has just reported data on the human level in the United States and Europe for the late summer and early fall of last year which amount to an average of about 75 micromicrocuries per gram of body potassium for an internal dose rate of about 3 milliroentgens per year. The total cesium-137 fallout in the United States now amounts to about 50 millicuries per square mile. This adds about 1 mr/yr of external dose for a total of about 4 mr/yr due to cesium-137, which is about 3 percent of the natural average radiation dose rate from natural radioactivity and the cosmic rays. I can't tell whether these numbers are in strict keeping with your estimate that the immediate probability of any one individual being affected by bomb-test carbon-14 and cesium-137 is about 1 in 500,000 but I think your estimate looks reasonable.

On the many other points in your letter I find myself in complete agreement, particularly about the importance of more experimental and collecting programs on the amount of fallout deposited locally from a low height of burst. Since it may be that we will not again have the opportunity to test devices, at least above ground, it is particularly important to consider whether we may not collect more information at this point from past tests. I believe there are some possibilities of doing this and I suggest that we undertake such a program jointly right away.

Sincerely yours,
W. F. LIBBY

Commissioner, Atomic Energy Commission

Young Research Workers for Government Laboratories

As the result of its first use of the Research Scientist Examination, the Civil Service Commission has 105 of the 200 young research workers it started searching for last December. The successful applicants, selected from a group of 370 who took the test, are now qualified to be considered for assignment to 11 federal laboratories in the Washington, D.C., area. They will be given opportunity to begin research work with a starting salary of $5430. Placement has already begun. A second and last test was administered to 690 persons in late March; 100 additional applicants are expected to qualify.

New Program

The two tests are part of a new personnel program conducted by the Civil Service Commission for 11 Washington area laboratories which need young research workers. The National Bureau of Standards, the National Institutes of Health, the Naval Research Laboratory, and 8 other agencies compose the interested group. The recruiting program is unusual in that it offers high starting salaries, direct entry into research positions, and thorough and imaginative testing of the applicant's research potential. Persons taking the positions will be given the opportunity to continue their formal education beyond the bachelor's degree. The 11 scientific facilities plan to devise means by which advanced study can be undertaken; in some cases it is expected that the worker's laboratory project will be applicable to his degree requirements.

Unlike other Civil Service programs, which use academic records as the primary basis of selection, the new recruiting system requires the applicant to take two tests. The first examines for knowledge of the subject matter of either chemistry, physics, or mathematics, or a combination of the first two. The second test examines for skill at mathematical formulation, an ability that has been found to have a high correlation with creative research potential.

Wide Range of Colleges

A remarkably wide range of colleges was represented by the first group of applicants for the commission's test given last February. More than 150 institutions were listed as the last school attended; 73 colleges had educated the 105 applicants who passed. The major universities of the country had only a limited representation on the list, which was composed to a considerable extent of small colleges such as Alverno, Loras, Wofford, and Canisius. Albert Maslow of the commission's test development section has speculated that this preponderance of smaller institutions might have been caused by two things, among others; the fact that the large colleges and universities have large and effective senior placement services, and the fact that the small colleges are probably less often visited by industrial and governmental recruiting teams. The small college man, in other words, has to go out and look for a job, and the commission's program, with its high salaries, was apparently quite attractive.

Success of Test

Working with preliminary data, the Civil Service Commission's testing experts feel that the tests, collectively called the Research Scientist Examination, show promise of considerable success. Although the final evaluation can only be made after the successful applicants have been working for a number of years, other information now available indicates that two major aims have been accomplished. The first is that the test drew persons from the age group that the designers had in mind. The great majority of the applicants were 22 or younger, and were in their last year of college or their first year of postgraduate work. A questionnaire, which was given with the tests, shows that the majority of the applicants, particularly those taking the physics subject matter, want to do postgraduate work. Success of the test is also indicated by the fact that among 35 percent of those that received high scores in the examination reported themselves to have been in the top quarter of their college class. Similarly, 44 percent of those who did well in the test had received Phi Beta Kappa citations, had graduated with honors, or had received other recognition for scholarship. Those with lower class standing and those with no scholarship citations did not do as well. In the view of the commission's experts, these findings suggest that the subject-matter tests gave an accurate measure of the applicant's knowledge of his field. The mathematical formulation test is another case. Only time will tell if it successfully identified those with creative research potential in this group as it has in past groups.

Commission personnel also feel that the combined tests effectively compensate for the differing standards at various schools. This problem, difficult with just two different institutions, was compounded by the great number of parent institutions listed by the applicants.

Also, the tests showed that a small number of people who were in the lower half of their class did very well on the examination. In the physics examination, for example, three of the 16 persons who received the highest scores were in the third or fourth quarter of their class. For these reasons, and because of the heavy response to its new program, the commission believes that it will be able to

provide the 11 laboratories 200 research workers who will have high potential for creative research.

"GeoScience Abstracts"

GeoScience Abstracts is the new monthly abstract journal that has been started by the American Geological Institute to replace *Geological Abstracts*, which had been published by the Geological Society of America for the member societies of the AGI since 1953. The launching of the reorganized and expanded journal has been made possible through a grant from the National Science Foundation.

At the outset, *GeoScience Abstracts* will work toward complete coverage of North American geological literature; abstracts translated from the Russian abstract journal, *Referativnyi Zhurnal*, will also be included as the translations are processed by the AGI Translation Committee.

The new journal will feature organization of abstracts into 15 subject sections, and the objective is to cover geology, solid earth geophysics, and related areas of science. An effort will also be made to provide effective coverage of geologic maps.

The cooperation of all regular geology-geophysics and other scientific journals is being sought, as is the aid of all appropriate government agencies in Canada, Mexico, and the United States. Colleges and universities that publish research results are being invited to contribute. The success of *GeoScience Abstracts* will depend upon the cooperation of the profession. For subscription information, write to the AGI, 2101 Constitution Ave., NW, Washington 25, D.C.

Public-School Enrollment

Public-school enrollment in this country was approximately 1,843,000 over the normal classroom capacity of the public elementary and secondary schools as the current school year began, compared with an excess enrollment of 1,943,000 in the fall of 1957. This was shown in reports from the states in the Office of Education's fifth annual survey of public-school enrollment, teachers, and school housing (Office of Education Circular No. 551).

The number of public-school pupils in excess of public-school classroom capacity was 5.4 percent of the total enrollment in the fall of 1958, compared with 5.9 percent in the fall of 1957. Twenty-four states reported that the number of pupils in excess of public-school capacity had been reduced as school opened last fall, while 18 other states and the District of Columbia reported an increase in excess enrollment. One state reported no change, and for five states comparisons were not possible.

The states reported a need for 140,500 additional instruction rooms, compared with 142,300 a year ago. Of the 140,500 rooms needed at the beginning of the current school year, 65,300 rooms were needed to accommodate the 1,843,000 pupils enrolled in excess of normal capacity and 75,200 to replace facilities considered obsolete or otherwise unsatisfactory.

Enrollment in the public schools increased 1,148,000 over the previous year. The states reported about 33,936,000 pupils enrolled in the fall of 1958, an increase of 3.5 percent over the previous fall.

The number of classroom teachers rose from about 1,253,000 in the fall of 1957 to about 1,300,000 in the fall of 1958, an increase of 47,000 or 3.8 percent. Overall, the pupil-teacher ratio was 26.1 in the fall of 1958, compared with 26.2 in the fall of 1957. The proportion of teachers with less than standard certificates declined from 7.3 to 7.1 percent.

Kitt Peak Observatory

Astronomers may now submit requests for use of the facilities at Kitt Peak National Observatory. Observing can probably begin about January 1960. Observing time can also be assigned to a limited number of graduate students. Subject to the availability of funds, travel expenses and subsistence will be granted to students.

The 36-inch and the 16-inch telescopes at the observatory will be equipped for ultraviolet-blue photometry with refrigerated photomultipliers. A classification spectrograph will be added to the large telescope shortly after January 1960. A ratio spectrometer is currently available on the small telescope, and a similar unit will soon be added to the large one.

Requests for further information and applications should be sent to the Director, Kitt Peak National Observatory, 1033 North Park Ave., Tucson, Ariz.

Federal Council for Science and Technology Established

On 13 March President Eisenhower signed the executive order that brought the recommended Federal Council for Science and Technology into being. The new council, which will have James R. Killian as chairman, has the responsibility of promoting coordinated policy planning for the many federal agencies engaged in scientific and technological work. The recommendation for the establishment of the group was made last December by the President's Science Advisory Committee.

The council will be composed of eight members representing the following departments and agencies: Departments of Defense, Interior, Agriculture, Commerce, and Health, Education, and Welfare; the National Science Foundation; the National Aeronautics and Space Administration and the Atomic Energy Commission. In addition, the executive order authorizes the Secretary of State and the director of the Bureau of the Budget to send observers to the council meetings.

In its last section, the order states: "The council shall be advisory to the President and to the heads of federal agencies represented on the council; accordingly, this order shall not be construed as subjecting any agency, officer, or function to control by the council."

Associated Colleges of the Midwest

The Ford Foundation has granted $525,000 to help ten private Midwest colleges launch a broad cooperative plan to improve their educational and financial problems. The grant went to Cornell College, Mount Vernon, Ia., which is the fiscal agent for the group, known as the Associated Colleges of the Midwest (ACM). The grant will cover the basic operating costs of the organization for 5 years. The group will raise matching funds to be used for special projects and later operations.

Besides Cornell College, the other colleges are Beloit (Beloit, Wis.), Carleton (Northfield, Minn.), Coe (Cedar Rapids, Ia.), Grinnell (Grinnell, Ia.), Knox (Galesburg, Ill.), Lawrence (Appleton, Wis.), Monmouth (Monmouth, Ill.), Ripon (Ripon, Wis.), and St. Olaf (Northfield, Minn.). Together, they enroll 10,000 students and have about 700 faculty members.

The aim of the ACM members is to achieve steady improvement in the quality of their educational programs through strengthening and making the best use of their available resources. The assumption is that they can accomplish some things collectively that they cannot do as well singlehandedly. Although ACM will conduct joint studies and experiments and certain joint operations, each member college will retain full independence of control over its own affairs.

The studies may cover such topics as trends in academic courses, the relation of size to costs, alternatives to the conventional academic year, utilization of facilities, the effects of varying class

size, effect of independent study by students, faculty salaries, standardized accounting practices, tuition, scholarships and loans, sources of funds, and investment policies.

Among the possible joint operations ACM may undertake are standardization of admission procedures and scholarship qualifications, pooling of library resources, joint offices for recruiting students, sharing of faculty members, expansion of cooperative arrangements for purchasing, research, faculty recruitment, and fund raising. The ten colleges may also explore the usefulness of a joint press, a summer school held on a different campus each year, a uniform calendar or a three-term-per-year plan, and interchange of lectures, concerts, and other extracurricular activities.

Los Alamos Accident

The Los Alamos Scientific Laboratory has completed its investigation of the circumstances surrounding the radiation accident which occurred at the laboratory on 30 December 1958, which resulted in the fatal injury of one employee. A technical report describing in detail the circumstances of the accident has been prepared and is available (50¢ per copy) at the Office of Technical Services, Department of Commerce, Washington 25, D.C. This report describes the events leading to the accident, the situation at the time of the critical burst, the removal and analysis of the solution that caused the burst, and the steps being taken to prevent a recurrence. Medical and pathological data resulting from studies now being carried on by the laboratory's health division will probably be ready for publication by midsummer.

An investigation review committee has found that the accident was directly attributable to errors on the part of the operator during a series of transfers of plutonium and organic solutions between containers in a chemical plutonium recovery process. The committee also found that the procedures for this process were such that safety of operation depended substantially on the ability and judgment of individual operators, but that the incident might have been prevented had the organizational arrangement required closer supervision to insure that normal procedures were followed.

Woodrow Wilson Fellows

The Woodrow Wilson National Fellowship Foundation, Princeton, N.J., has announced the names of 1200 American and Canadian students as Woodrow Wilson fellows. The foundation recruits promising students who intend to be teachers and supports them for their first year of graduate study. The project is backed by a $25-million grant from the Ford Foundation.

It has been predicted that between 30,000 and 40,000 new full-time college teachers will be needed to train the wave of students seeking college educations in the 1960's. The current annual output of Ph.D's averages 9000, of which only half go into college teaching.

This year's Wilson fellows were chosen from 7000 candidates from more than 700 undergraduate colleges. New Wilson fellows will begin graduate work next fall at 80 different universities. Each fellow receives a living allowance of $1500, plus the full cost of tuition and fees. Married students receive additional stipends.

In this year's group of winners there are 875 men and 325 women. Of these, 38 percent are planning to take courses in the humanities, 34 percent, in the social sciences, and 28 percent, in the natural sciences and mathematics.

Nuclear Information Center

An information center has been opened by the United Kingdom Atomic Energy Authority at 11 Charles II St., London, S.W. 1, that provides a central location where published unclassified material may be consulted with no security restrictions. Advice on sources of information is also given. A collection of unclassified reports, indexes, and abstracts of atomic energy literature, and publications on the work of the AEA, are all on file.

Adjoining the center is an 8000-print photographic library. Prints may be bought from stock or ordered to suit particular requirements. Slides in color and black-and-white may be borrowed.

British Association for Medical Education

The Association for the Study of Medical Education in Great Britain, organized late in 1957 to serve as a forum for persons interested in the problems of medical education and as a clearinghouse for information in the field, will be assisted during its initial, developmental years by a grant of £10,000 (about $28,500) from the Rockefeller Foundation to The Royal College of Physicians, London. The major purposes of the association are to exchange information on medical education in Great Britain; organize meetings on relevant topics; maintain a bureau where information can be received, stored, and made available to those interested; and encourage, promote, or conduct research into matters concerned with medical education. Almost all the licensing bodies and medical schools of Great Britain, as well as individual medical educators and practitioners, are members of the new association.

Research Associateship Program

A program of research associateships, offering stipends of $8000 and more a year and opportunities for work in the sciences bearing on space exploration, has been announced by the National Academy of Sciences–National Research Council and the National Aeronautics and Space Administration.

The associateships, which will involve both theoretical and experimental research at NASA's Beltsville, Maryland, Space Projects Center, are being offered to two groups—those who are at the immediate postdoctoral level and those who are well-established investigators in disciplines germane to space exploration. Associateships for the first group, designated "regular," will carry the stipend of $8000 a year, the normal period of tenure; those for the second group, the "senior" associateships, will carry stipends adjusted to match the individual's salary.

Applicants for the regular associateships must produce evidence of training equivalent to that represented by the doctorates of philosophy or science or must have completed the requirements for one of these degrees at the time of entering upon the position. In addition to the documents normally required for such an application, a plan of research to be conducted at the NASA laboratory must be submitted. Selection of the senior associates will be based on letters of recommendation and evidences of previous scientific accomplishments and scholarly activity. The applicants will be evaluated and passed on by a board appointed by the National Academy of Sciences–National Research Council; in all cases they will be expected to have demonstrated superior ability for creative research.

Successful applicants in this program will work at the NASA Space Projects Center in either the space sciences division, under J. W. Townsend, or the theoretical division, under Robert Jastrow. In Townsend's division, which does experimental work, suitable areas for research would be fields and particles, planetary atmospheres, astronomy, solar physics, and meteorology. The moon and planets, astrophysics, and plasma physics will be the concerns of the associates working in the theoretical division. It is expected that later appointees will take

part in additional activities in NASA.

Applications should be received by 30 April 1959. Requests for applications and further information should be addressed to Fellowship Office, National Academy of Sciences–National Research Council, 2101 Constitution Avenue, NW, Washington 25, D.C.

News Briefs

The Geneva conference for a ban on nuclear weapons tests went into recess on 19 March. Before adjourning, the conferees—representatives from England, the United States, and Russia—adopted three articles of a draft treaty. This brings to seven the number of articles accepted during the 72 meetings of the current period of negotiation. The three new points are that the proposed treaty should be of indefinite duration, that it should be registered with the United Nations, and that the control system should be reviewed after 2 years. The conference, which was recessed at the request of England and the United States, will reconvene on Monday, 13 April.

* * *

The United States has authorized the transfer to the United Kingdom of a complete nuclear propulsion plant for installation in the United Kingdom's submarine *Dreadnought*. The reactor is similar to those being installed in the latest U.S. Navy submarines of the *Skipjack* class. Spare parts, the reactor core, technical and manufacturing assistance, and classified information, including restricted data related to the plant, will also be supplied. A main objective of the transfer is to provide the United Kingdom with assistance and knowledge to enable that government to speed the building of similar nuclear propulsion units for use in submarines of the Royal Navy.

* * *

A radar photographic system that, by using four aircraft, could produce a reconnaissance map of an area as big as the United States is being developed for Britain's bomber force.

The project, which holds out promise of great civil as well as military rewards, was recently disclosed to the House of Commons in the Air Ministry's request for £491,000,000 ($1,374,800,000) in the 1959–1960 budget. In addition to its role of military reconnaissance for the Royal Air Force, the radar system could also be a valuable tool, it is believed, in any aerial inspection system arising out of a general disarmament agreement.

* * *

More than 9000 archeological sites—locations of Indian and frontier settlements—have been found in the past 12 years in areas scheduled to be flooded or otherwise obliterated in the present reservoir-building program, the Committee for the Preservation of Archeological Remains reports.

The sites are scattered over 310 reservoir areas in 42 states and constitute remains of camps, villages, burial mounds and other cemeteries, trails, quarries, and caves used by Indians; and trading posts, forts, pioneer cabins, and settlements of white frontiersmen.

Many of the 9000 sites obviously do not merit excavation, says the report. Those that do, if the work is carried out, "would provide a record of man's achievements in North America over a period ranging from 10,000 to less than 100 years ago."

* * *

The effectiveness of water treatment in the removal of radioactive waste materials is the subject of "Report of the Joint Program of Studies on the Decontamination of Radioactive Waters," a document jointly prepared by the health physics division of Oak Ridge National Laboratory and the Robert A. Taft Sanitary Engineering Center of the U.S. Public Health Service, and just issued by the Public Health Service. Official requests for copies will be honored by the Public Health Service and Atomic Energy Commission. The report is also available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., at $1.00 per copy (publication number ORNL-2557).

* * *

The Kaiser Foundation has announced the establishment of the Kaiser Foundation Research Institute (a division of the Kaiser Foundation Hospitals) with executive offices at 1924 Broadway, Oakland, Calif. The new institute incorporates, under the direction of Ellsworth C. Dougherty, the former Laboratory of Comparative Physiology and Morphology of the Kaiser Foundation, renamed the Laboratory of Comparative Biology. A second section of the institute, the newly established Laboratory of Medical Entomology, is under the direction of Ben F. Feingold. Both laboratories have headquarters at the Kaiser Foundation Medical Center, S. 14th St. and Cutting Blvd., Richmond, Calif.

Scientists in the News

GEORGE WALD, professor of biology at Harvard University, has received the 51st Rumford Premium of the American Academy of Arts and Sciences, for "perceptive studies through which he has illuminated the biochemical basis of vision." The premium, consisting of a $5000 award and a gold and silver medal, was presented at a meeting of the academy in Brookline, Mass., on 11 March.

CLIFFORD GROBSTEIN, professor of biology at Stanford University, is the recipient of the Albert Brachet Prize of the Belgian Royal Academy. The prize, which consists of 20,000 Belgian francs ($500), is given every 3 years for the most outstanding work in experimental embryology during that period. Grobstein is the first American among the eight scientists who have won the award during its 24-year history.

WILLARD F. LIBBY, scientist member of the Atomic Energy Commission and professor of chemistry at the University of California, Los Angeles, has been named the recipient of the 1959 Albert Einstein Medal and award, consisting of $5000. The award is given by the Lewis and Rosa Strauss Memorial Fund, which was established in 1951 by Lewis L. Strauss, former AEC chairman, in memory of his parents.

M. D. ARMSTRONG, officer in charge, Road Research Scottish Laboratory, Glasgow, Scotland, has been invited to give 30 lectures at Northwestern University, Evanston, Ill., from 1 April to 15 June.

JAMES C. LAMB, sanitary engineer with American Cyanamid Company, N.J., has been appointed associate professor of sanitary engineering at the University of North Carolina School of Public Health, Chapel Hill, N.C.

JOHN G. N. BRAITHWAITE, formerly with the electronics division of the Canadian Westinghouse Company, has joined Baird-Atomic, Inc., Cambridge, Mass., as senior infrared scientist.

EDGAR ZWILLING, associate professor of animal genetics at the University of Connecticut, has been appointed professor of biology at Brandeis University, effective 1 July.

The following scientists were among the winners of Rockefeller Public Service Awards:

DEAN R. CHAPMAN, aeronautical research scientist, National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

CHARLES L. CHRIST, physicist and laboratory director, Geochemistry and Petrology Branch, U.S. Geological Survey.

MARVIN A. SCHNEIDERMAN, section head, Cancer Chemotherapy National Service Center, National Cancer Institute, National Institutes of Health.

W. DAYTON MACLAY, director of U.S. Department of Agriculture's Northern Utilization Research and Development Division, Peoria, Ill., has been

appointed assistant administrator of the Agricultural Research Service. He succeeds GUIDO E. HILBERT, who recently was appointed director of the Foreign Research Contracts and Grants Program. FREDERIC R. SENTI has been named acting director of the Northern Utilization Research Laboratory.

PETER C. KRONFELD, professor of ophthalmology at the University of Illinois College of Medicine, has been appointed head of the department of ophthalmology and ophthalmologist-in-chief at the university's hospital and at the Illinois Eye and Ear Infirmary.

FREDERICK C. NACHOD, director of the physical chemistry laboratory at Sterling-Winthrop Research Institute, New York, and adjunct professor of chemistry at Rensselaer Polytechnic Institute, has been awarded the Order of Merit of France's Society for Encouragement of Research. The award is offered annually and is sponsored jointly by France's Ministries of Education, Industry, Commerce, and Public Health.

HERBERT C. BROWN, professor of chemistry at Purdue University and a specialist on the chemistry of boron jet-fuel material, has received the 1959 William H. Nichols Medal of the American Chemical Society's New York Section.

The following scientists were among the recipients of the 1958 Borden awards. These awards, consisting of a gold medal and $1000, are administered by professional and scientific associations. The 1958 winners were:

WILLIAM G. GORDON, supervisory chemist, Eastern Regional Research Laboratory, U.S. Department of Agriculture, the American Chemical Society award for contributions in the fundamental chemistry of milk products.

W. JAMES HARPER, associate professor of dairy technology, Ohio State University, the American Dairy Science Association award for contributions in dairy bacteriology and biochemistry.

JAY L. LUSH, professor of animal husbandry, Iowa State College, the American Dairy Science Association award for research in the genetics and breeding of dairy cattle.

MAY S. REYNOLDS, professor of foods and nutrition, University of Wisconsin, the American Home Economics Association award for research in protein metabolism.

LEMUEL D. WRIGHT, professor of nutrition, Graduate School of Nutrition, Cornell University, the American Institute of Nutrition award for the development of new microbiological assay procedures for various vitamins and the discovery of biocytin.

CHARLES D. MAY, clinical professor of pediatrics, College of Physicians and Surgeons, Columbia University, the American Academy of Pediatrics award for his contribution to long-term metabolic studies of infants fed with human milk.

CHESTER A. MANTHEI, U.S. Department of Agriculture, Beltsville, Md., the American Veterinary Medical Association award for research in the control and eradication of brucellosis in dairy cattle.

CURTIS B. THORNE, supervisory biochemist at the Army Chemical Corps Biological Warfare Laboratories, Fort Detrick, Frederick, Md., has received the 1959 Waksman Award of the Theobald Smith Society, which is the New Jersey section of the Society of American Bacteriologists.

The following scientists are among the winners of the National Civil Service League's fifth annual Career Service Awards. The league is a nonpartisan organization of citizens for good government. It makes the awards to federal employees "who exemplify the highest characteristics of public service." The winners were honored at a dinner on 2 March in the Sheraton Park Hotel, Washington, D.C.

LYLE T. ALEXANDER, chief of the Soil Survey Laboratories, Soil Conservation Service, Department of Agriculture. A government employee for 30 years, he has made outstanding contributions in the fields of soil management, soil genesis, clay minerals, and radioactive materials.

JOHN B. BARNWELL, assistant chief medical director for research and education, Veterans Administration. He organized a model cooperative study of the chemotherapy of tuberculosis that "improved the treatment of TB and saved many lives and millions of dollars." In federal service for 16 years, he is now directing an extensive medical research program.

PAUL W. McDANIEL, deputy director, division of research, Atomic Energy Commission. In federal service 16 years, his efforts have "contributed much to the proper organization and operation of the Atomic Energy Commission to meet the challenges of new discoveries."

RICHARD A. WEISS, scientific director, Army Research Office, office of the chief of research and development, Department of the Army. He has "significantly advanced our defense capabilities, in such fields as optics, nucleonics, and electronics, and has encouraged the youth of the Nation to develop scientific talent."

CONRAD L. WIRTH, director, National Park Service, Department of the Interior. His citation reads: "Having devoted 30 years of public service to the conservation of the Nation's human, cultural, and natural resources, Wirth has given new vitality to the whole program of the National Park Service."

Recent Deaths

CORNELIA C. BRANT, New York; 95; formerly dean of the New York Medical College and Hospital for Women (now consolidated with Flower and Fifth Avenue Hospitals); one of the first three women named to a public hospital staff in New York; 9 Mar.

MYRON GORDON, New York; 59; geneticist and principal investigator for the National Cancer Institute; genetics associate of the American Museum of Natural History, the New York Zoological Society, and the New York Aquarium; taught at New York University and at Columbia University; 12 Mar.

WILFRID J. JACKSON, New Brunswick, N.J.; 58; specialist on radar; chairman of the physics department at Douglass College, since 1946; head of the scientific division of the New York branch of the Office of Naval Research in 1950; formerly associate professor in the radar school of Massachusetts Institute of Technology; had taught at Princeton and Rutgers universities; 13 Mar.

JOHN C. KELLER, Utica, N.Y.; 60; chairman of the chemistry department at Utica College since its establishment in 1946; had been director of the chemistry department at Muhlenberg College for 20 years; 10 Mar.

WARREN W. McSPADDEN, New York; 55; general manager and assistant treasurer of the American Society for the Prevention of Cruelty to Animals; formerly supervisor of sciences in the public schools of Austin, Tex.; had taught at Teachers College, Columbia University; 12 Mar.

EVERETT I. YOWELL, Cincinnati, Ohio; 89; retired in 1940 as head of the astronomy department and as director of the observatory at the University of Cincinnati; vice president of section D of the AAAS in 1939; faculty member of the mathematics department of the U.S. Naval Academy, 1901–09; 12 Mar.

WILLIBALD WENIGER, Corvallis, Ore.; 74; retired in 1949 as dean of the Oregon State College Graduate School; had been connected with the university for 35 years; professor of physics and acting director of agriculture, forestry and engineering at Idaho State College, 1956; head of the physics and electrical engineering departments at the University of Alaska, 1951–55; 13 Mar.

Erratum: The item on the cloud-cover satellite [*Science* **129**, 628 (1959)] gave a perigee of 929 miles. The correct figure as of 17 March is 350 miles.

Book Reviews

Basic Facts on Productivity Change. Solomon Fabricant. National Bureau of Economic Research, Inc., New York, 1959. viii + 49 pp. $1.

When you listen today to the discussion of any burning professional economic problem by economists or laymen it will not be long before you hear the word *productivity*. Wage rate increases in excess of productivity gains cause inflation. Productivity must be raised if the West is to win the battle of production with the nations of the Communist bloc. Productivity must rise if production in the underdeveloped countries is to match or exceed the population growth. If productivity increases as in the past, the American economy will grow by 40 percent over the next decade. Productivity, it seems, is the key to the solution of many economic problems.

The National Bureau of Economic Research has initiated a number of research projects which have a bearing on the measurement of changes in productivity. These studies will appear in voluminous tomes over the years; meanwhile the debate about productivity goes on without benefit of these research studies.

In this situation it is highly welcome that Solomon Fabricant, director of research of the National Bureau, presents in a small pamphlet the main findings of the several research studies which are under way. All students of the topic will find here in concise form a summary of the pioneering work done in this field, by John W. Kendrick, in particular.

However, the layman who is lured to this pamphlet by the author's promise to state the findings "in a minimum of technical language" (page 3) will be more exasperated than enlightened by some aspects of the study. If he is looking for advice on how to measure productivity, he finds not one measurement but 46 in the first summary table. Let me hasten to add that I do not criticize the author for presenting various ways in which productivity can and should be measured. Indeed, I believe that this concept has different meanings and requires different measurements depending on whether it is used, for example, in a discussion of the effects of next year's wage rate increases, or in an international comparison, or in projecting the growth of an economy. More guidance would have been helpful in determining which measurement is most suitable for which purpose.

The summary table presents annual long-term productivity gains of between 0.7 and 2.3 percent for the period from 1889 to 1953. The most refined measurements give an average between 1.4 and 1.7 percent. It seems that the author believes that only these figures should be used, rather than the 2.3 percent which results from the conventional measurements.

The conventional measurement of productivity simply divides the dollar value of total production by the number of man-hours worked in an industry or in the economy as a whole. In order to make comparisons over time meaningful, the dollar values are expressed in constant prices; in order to make international comparisons of productivity levels meaningful, the values have to be expressed in some comparable money unit. An increase in productivity thus measured does not necessarily mean that employees have worked that much harder or that much more skillfully. The increase in productivity may be due also to the increased use of capital equipment, to technological and managerial innovations, and to many other factors. Productivity gains may be held up, however, if real costs of production or distribution rise—for example, through the use of lower-grade raw materials, through more costly transportation, through increased sales effort (advertising), and so on. What we measure is the net gain in all these factors.

The National Bureau studies have brought a threefold refinement of this conventional measurement of productivity. First, it is proposed to use a "weighted" measurement of man-hours, which takes account of changes in the relationship between more or less skilled labor (using wage and salary rates for measuring differences in skills). The second, even more important, refinement consists in computing the increase in production not only per man-hour worked but also per unit of tangible capital. These two productivity measurements are then combined into one ratio which expresses the extent to which total production has increased over and above the weighted increase in man-hours worked and the increase in tangible capital. A third kind of refinement relates to a special treatment of defense production in the production total. This refinement is understandable only to students familiar with previous National Bureau publications. It is used but not explained in the present pamphlet.

The second refinement, the introduction of a productivity ratio of an increase in output related to an increase in tangible capital, is the most significant innovation introduced by the National Bureau studies. In virtually all instances in which productivity ratios have been used heretofore—in connection with wage rate increases, inflation, international comparisons, and economic projections into the future—the conventional measurement has been used. Is the conventional measurement obsolete and should the refined measurement be used from now on for these various purposes? Although the author does not directly answer this question, the reader gets the impression that wrong answers are obtained if the conventional measurement of productivity is used. I will briefly attempt to give my own answer, because of the crucial importance of productivity measurements for so many timely issues of practical economics.

Let us first assume that we are comparing productivity gains of two countries—one of extreme capital scarcity, the other, of capital abundance. In the country of capital scarcity most work is done by labor; the installation of additional machinery is kept to a minimum. In the country of capital abundance more machinery is installed year after year. Gaged by the conventional measurement, productivity gains very little in the first country; it increases rapidly in the second. If the country of capital scarcity should be tempted by the comparison to install more machinery, it may be making a mistake, because its economic structure may be such that it should make the most efficient use of labor rather than replace labor by machines. The refined measurement would more accurately indicate the comparative advancement in efficiency of the two countries. (This simplified example should not be construed as a position on my part with respect to the question of whether adoption of modern technology is desirable for overpopulated and underdeveloped countries.) If we compare productivity development in countries or time periods of substantially different economic structure, the refined method of measurements presents an advancement over the conventional, cruder method.

As a matter of fact, Fabricant does use the combined index for a very illuminating long-range historical analysis

of the relationship between productivity gains and the rise in real earning in the economy as a whole and in selected industries. These findings give what is probably a more accurate picture than previous studies made with less refined statistical methods.

Let us now consider the subject of productivity gains in connection with agreements in wage rate increases. Let us assume that labor unions and management have agreed on increases in wage rates in proportion to the increase in productivity in the economy as a whole. What difference does it make whether the conventional or the refined method of measurement is used? If the conventional method is used for determining a wage rate increase, labor participates pro rata in the net gains in production attributable to the installation of new machinery, to technological and managerial improvements, and to all other factors making for an increase in production per unit of tangible capital invested and per man-hour worked. The corporation, on the other hand, *shares* in the contribution of a greater labor effort. Basically the percentage distribution of incomes between labor and capital remains the same.

If the refined measurement is used, labor would not participate in the production gains attributable to a larger investment in tangible capital per worker. Labor would gain pro rata through improvements in the efficiency of management and in the technological qualities of plant and equipment. Use of productivity ratios for an appraisal of wage rate increases is by its nature a short-run application. In the short run, very drastic changes in the relationship between labor and capital cannot be assumed. Therefore, the assumption of a constant distribution between capital and labor should not cause a very serious error in a short-range analysis. On the other hand, the use of a measurement of capital productivity resting on only crude tangible capital data does introduce a source of possibly serious error into the calculation.

The capital productivity ratio which is combined with the man-hour productivity ratio is based not on tangible capital actually used but on that available (footnote, page 14). Thus, the refined productivity measurement is a combined measure of production in relation to man-hours *actually worked* and of production in relation to tangible capital *available*, irrespective of the degree of its utilization. It would be justifiable to measure production in terms of available factors of production (manpower and machines) as an expression of the efficiency of the economic system. The combination of one factor actually utilized with another factor available introduces an error in the computation which may be less than the error committed if different countries or distant time points are compared with the use of the conventional period. The error of the refined method may, however, be larger than the error of the conventional method for short-range analyses.

Also, as a tool for long-range economic projections the use of the conventional method is justified as long as the economic analyst is fully aware that the rate of productivity growth thus measured includes the effect of changes in the tangible investment per worker in addition to all other factors which make for either increased or decreased net output. For a projection into the future it would be best if each of these factors could be appraised separately.

A mechanical extrapolation of the refined index of productivity is not much better than an extrapolation of the cruder index. The latter has the advantage that it can be taken as a point of departure for studying each of the factors which enter its determination, including changes in tangible capital per worker, the efficiency of capital, the efficiency of management, and all other factors. In any case, a projection must consider separately the trends in the ratios of capital stock to output and of man-hours to output. But no particular advantage would be gained by using the combined index for this purpose.

The refinements in productivity measurements proposed through the various studies of the National Bureau and summarized in this pamphlet have substantially contributed to our understanding of the problem and have provided us with tools for measurement that are of great value for certain problems. The conventional method of productivity measurement is, however, not yet obsolete and probably will continue to be most suitable for most practical purposes. Fabricant failed to discuss the purposes for which the various methods of measuring productivity are most suitable. This is my only criticism of an otherwise extremely useful publication.

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Medical Education. Annotated bibliography, 1946–1955. World Health Organization, Geneva, Switzerland, 1958 (order from Columbia University Press, New York). 391 pp. $6.75.

The basis for this select bibliography was a search of the world literature on medical education published between the years 1946 and 1955. Over 4000 references were collected. Virtually all of them were examined, and 2500 were selected for listing in this bibliography.

The references are classified alphabetically by author under the following headings: "History of medical education"; "Aims, trends, and general considerations"; "Special subjects" (for example, allergy, anesthesiology, bacteriology); "Pre-medical education"; "Students"; "Teachers"; "Curriculum"; "The patient in medical education"; "Academic teaching"; "Audio-visual aids"; "Research in medical education"; "The medical school in the community"; "Internship and licensure"; and "Countries and continents." An author index is included.

Brief annotations are given for all articles written in a language other than English, or, in the case of works published in English, for articles whose scope cannot be deduced from the title.

The Physics of Elementary Particles. J. D. Jackson. Princeton University Press, Princeton, N.J., 1958. ix + 135 pp. $4.50.

This concise survey of elementary particle physics had its origin in a series of lectures given at the summer seminar of the theoretical physics division of the Canadian Association of Physicists in 1957. The emphasis tends to be on recent developments; for example, the author gives considerable attention to the formulation of the theory of β-decay required by the experimental asymmetries that demonstrate nonconservation of parity.

The book is divided in three parts. The first outlines the interpretation of results on pion-nucleon scattering and on photoproduction of pions from nucleons. The second discusses K mesons and hyperons in terms of the Gell-Mann classification scheme and several models that have been proposed for the strong interactions of these "strange" particles. The third part is devoted to weak decay processes. Both the β-decay of nuclei and meson and hyperon decays are discussed, with emphasis on the nonconservation of parity. Among the topics that are omitted are nucleon-nucleon forces, antinucleons, and the production of pions in nucleon-nucleon collisions. In general, experimental methods are not described, but experimental results are quoted whenever necessary to justify or illuminate the development of theoretical ideas.

The result is a logical and consistent presentation of the areas in which understanding of elementary particles has been advanced most significantly during the last decade. As an introduction to the field of elementary particle physics the book will be of somewhat limited usefulness, since a good working knowledge of quantum mechanics, nuclear

physics, and at least classical field theory is required of the reader, and the concise presentation makes few concessions to his weaknesses. It cannot be expected to serve as an account for the general reader, for the undergraduate in physics, or even for most scientists trained in fields other than physics. For those with adequate background, however, it should prove to be a valuable discussion of a field in which good books are rare. To some extent it may serve as a sequel to Fermi's similar book, '*Elementary Particles*,' published eight years ago.

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The Central Nervous System and Behavior. Transactions of the first conference, 23–26 February 1958. Mary A. B. Brazier, Ed. Josiah Macy, Jr. Foundation, New York, 1959. 450 pp. Illus. $5.25.

This is a remarkably fine, interesting book. It is crammed with provocative ideas on the central nervous system and behavior—the functions of man that presumably give him status in the animal world. The contributions of the Russians are the springboard—immediately apposing their scientific and political behavior and ours. The discussions are soundly rooted in the rich soil of history. There is a pictorial survey of over 100 pages, starting with the seal of the first Italian scientific academy and ending with a panorama of Moscow University, which presents the Russian intellectual heritage in science better than any other single reference in English with which I am acquainted. Recognition of the true place of Lomonosov, Sechenov, Pavlov, and even Popov (the Russian counterpart of Marconi) among the important minds that have advanced all mankind may some day replace the propaganda distortions from the Kremlin and the uninformed journalistic outcries that serve as the Western answers.

The second portion of the book brings up to date the important modern developments of post-Pavlovian physiology: brain stimulation and conditioned reflexes, electroencephalographic studies, and electrical correlates of conditioned learning. Although these three chapters are attributed to Robert W. Doty, Frank Morrell, and Robert Galambos, respectively, they are "group interchanges" in the now-familiar style of the Macy conferences. The naturalness and the clarity of the presentations reflect great credit upon the editor, Mary Brazier.

The conference is brought to an integrated wholeness by a thoughtful summation, led by Robert Livingston. He contrasts the monistic Russian physiology with our fractionalized approach and develops this significant thought (credit for which he shares with Paul MacLean): "Perhaps because of our philosophical as well as physiological isolation of visceral and somatic mechanisms, our political tradition has tended to look upon somatic and visceral needs as rather completely independent. Our physiological philosophy has a certain impact and bears a certain responsibility in relation to our Government's political actions and diplomatic relations, and especially with respect to how, as a people, we communicate our ideals to others. This becomes of particular concern at the present in relation to how the United States is viewed by the so-called uncommitted countries. Russia has . . . been much more sensitive . . . to the importance of visceral well-being and to the relationships which they conceive to exist between the physiological and social integration of man."

To paraphrase the thought in a more concrete example: the ideals of free enterprise sound better on a full than on an empty belly, but the fullest belly will not offset the insult of being considered inferior. The psyche and the soma are indivisible, and both must be satisfied.

If, indeed, science has a role as a bridge of understanding between the two great systems of politics confronting each other with gestures that augur ill for mankind, the area of investigations of the central nervous system appears to be particularly fruitful. It would be useful indeed if all American scientists read with care the proceedings of this conference. As a reviewer I have urged the translation into English of many a Russian book; this is one which we could profitably translate into Russian if it were possible to place a copy in each scientific institute of the Soviet Union.

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Electric Conduction in Semiconductors and Metals. W. Ehrenberg. Oxford University Press, New York, 1958. x + 389 pp. Illus. $10.10.

The three most active periods in the development of theories of conduction of electricity in solids are reflected in Ehrenberg's book. In the early years of the century, Drude, Lorentz, and others based their calculations on a model in which the outer or valence electrons of the atoms in a metal become detached to form an electron gas, which was treated classically. Shortly after the discovery of quantum theory in 1926, Sommerfeld, Houston, Bloch, and others showed that many of the difficulties of the earlier theories could be removed by application of quantum statistics and by taking into account the wave nature of the electron. During the next several years the foundations of the modern theory of solids were laid down and a number of excellent texts and treatises appeared. Basic to most of this work was the Bloch or one-particle approximation, in which correlations between positions of the electrons are neglected. In general, with a few notable exceptions, agreement between theory and experiment was qualitative rather than quantitative.

The past decade has been another active period, particularly in the field of semiconductors. Extensive theoretical developments, based largely on Wilson's (1931) energy band model, and well-controlled experiments with exceptionally pure single-crystals, have brought about a close coordination of theory and experiment. Recent work on the many-body problem has helped remove some of the limitations of the one-particle theories.

In the first four chapters, Ehrenberg discusses the theory of conduction in ionized gases, which is in many ways analogous to that in semiconductors, and presents in more detail than seems necessary the classical Drude-Lorentz type theory, with some modifications for quantum statistics and two-carrier models. Chapters 5 through 9 outline the wave-mechanical treatment. The one-particle approximation is used throughout, without apology or explanation. The last four chapters (10 through 13) cover some of the postwar experimental and theoretical work on semiconductors and transistor electronics. It is unfortunate that a book on such an active field should have been so long in preparation. It is evident that most of the text must have been written in 1955 or earlier; the latest date in the bibliography is 1955.

While the book has some valuable features, it is on the whole unsatisfactory. Theoretical derivations often are given in great mathematical detail, but uncritically and without first giving the reader an understanding of what is to be accomplished and what physical assumptions are involved. The book would be difficult for a beginner in the field and, moreover, not very rewarding if the aim is to get a real understanding of what has been accomplished and what outstanding problems remain. It is probably most useful as a reference volume or for supplementary reading on particular topics. The book is beautifully printed, in keeping with other Oxford University Press volumes.

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Perception and Communication. D. E. Broadbent. Pergamon, New York, 1958. 338 pp. $8.50.

Potential readers may be misled by the title of this book, particularly if they think of "perception" in a general sense and of "communication" as involving interactions among two or more people connected by a channel. The author treats the individual as the channel and is concerned with interrelations among and between input events and output events. A more appropriate title would have been "Auditory Perception and Behavior," and as a sample of the chapter headings indicates—"Selective listening to speech," "Effects of noise on behavior," "The nature of vigilance," "The nature of extinction," "Recent views on skill"—the book serves as a vehicle for review and interpretation of specific research areas in which the author has worked.

This does not mean that the reader, particularly if he is conversant with research in psychoacoustics and in human learning, will be disappointed. Broadbent places his own research in an information-theory context and relates it to much of the significant research of others. Especially rewarding are experimental studies on the central effects of listening to two messages, on the assessment of human channel capacity by effects on simultaneous tasks, and on short-term and long-term storage capacity of the organism as revealed by reproduction of information put into the two ears simultaneously.

Broadbent attempts to encompass these and other experimental findings within what he calls a "filter theory." According to this view, the nervous system operates as a single communication channel having a limited capacity. Incoming information is selected in terms of certain common features (for example, intensity, pitch, spatial localization) of the sensory events and in terms of the (drive) states of the organism. The conditional probabilities among successive events are stored on a relatively long-term basis, the predictabilities between cues and reinforcing states of affairs being one important class of such conditional dependencies. A shift in selection from one class of sensory events to another takes time and is accompanied by "inattention."

This is a very concentrated book—little space is wasted on padding or on elaborating the obvious. The information-theory type interpretation seems more convincing when applied to psychoacoustic phenomena than when applied to learning phenomena (for example, extinction, spontaneous recovery, reinforcement). Much of the research reported was done under the aegis of military and industrial organizations, and the author tries to provide an interpretive theoretical framework. Opinions will vary as to the success of the attempt, but Broadbent's contribution to our empirical knowledge of auditory perception, storage, and reproduction under complex conditions will be appreciated by all readers.

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New Books

Advances in Biological and Medical Physics. vol. VI. Cornelius A. Tobias and John H. Lawrence, Eds. Academic Press, New York, 1958. 648 pp. $16.50. Contents: "Ion and water transport in stomach and intestine" (R. P. Durbin, Peter F. Curran, A. K. Solomon); "Artificial and induced periodicity in living cells" (E. Zeuthen); "Radiobiological aspects of the induction of lysogenic bacteria to produce phage with x-ray, gamma ray, and ultraviolet radiations" (H. Marcovich and R. Latarjet); "Cell studies with microspectrography" (B. Thorell); "Some aspects of the effect of ionizing radiation on tumors in experimental animals" (O. C. A. Scott); "Fallout from nuclear weapons tests" (C. L. Dunham); "Radiological contrast enhancing methods" (B. Jacobson and R. S. Mackay); "Quantitative measurement of regional circulation in the central nervous system by the use of radioactive inert gas" (W. H. Feygang, Jr., and L. Sokoloff); "Intense ultrasound in investigations of the central nervous system" (W. J. Fry); "Isotopic tracers in the study of diabetes" (S. A. Berson and R. S. Yalow); "Application of light scattering to biological systems: deoxyribonucleic acid and the muscle proteins" (E. P. Geiduschek and A. Holtzer); "Physical and chemical mechanisms in the injury of cells by ionizing radiations" (P. Howard-Flanders).

First Book of Grasses. The structure of grasses explained for beginners. Agnes Chase. Smithsonian Institution, Washington, D.C., ed. 3, 1959. 146 pp. $3.

General Chemistry. William H. Nebergall and Frederic C. Schmidt. Heath, Boston, 1959. 731 pp. $7.25.

The Gulf Stream. A physical and dynamical description. Henry Stommel. Univ. of California Press, Berkeley; Cambridge Univ. Press, London, 1958. 215 pp. $6.

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A History of Ophthalmology. George E. Arrington, Jr. M.D. Publications, New York, 1959. 191 pp. $4.

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Introduction to Chemical Engineering Thermodynamics. J. M. Smith and H. C. Van Ness. McGraw-Hill, New York, ed. 2, 1959. 502 pp. $8.75.

Modern Science and the Human Fertility Problem. Richard L. Meier. Wiley, New York; Chapman & Hall, London, 1959. 276 pp. $5.95.

The National Forests. Arthur H. Carhart. Knopf, New York, 1959. 301 pp. $4.75.

Oceanography and Marine Biology. A book of techniques. H. Barnes. Macmillan, New York, 1959. 218 pp. $7.

On Numerical Approximation. Proceedings of a symposium conducted by the Mathematics Research Center, U.S. Army, at the University of Wisconsin, Madison, 21–23 April 1958. Rudolph E. Langer, Ed. Univ. of Wisconsin Press, Madison, 1959. 472 pp. $4.50.

A Philosopher Looks at Science. John G. Kemeny. Van Nostrand, Princeton, N.J., 1959. 285 pp. $4.95.

Proceedings of the Symposium on Electronic Waveguides. New York, N.Y., 8–10 April 1958. Microwave Research Inst. Symp. Ser., vol. VIII. Jerome Fox, Ed. Polytechnic Press, Brooklyn, N.Y., 1958. 437 pp. $5.

Recognition of Diseases and Pests of Farm Crops. Ernst Gram, Prosper Bovien, Chr. Stapel. Published by the Danish Agricultural Information and Advisory Aids Service by Heffer, Cambridge, England, 1958. 128 pp. 35s.

Reprints

An Introduction to Fourier Methods and the LaPlace Transformation. Philip Franklin. Dover, New York, 1958. 289 pp. $1.75.

Introduction to Symbolic Logic and Its Applications. Rudolf Carnap. Translated by William H. Meyer and John Wilkinson. Dover, New York, 1958. 241 pp. $1.85.

Jordan. Its people, its society, its culture. George L. Harris. Grove Press, New York, 1959. 246 pp. $1.95.

Linear Groups with an Exposition of the Galois Field Theory. Leonard Eugene Dickson. Dover, New York, 1958. 312 pp. $1.95.

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Psychology of Personality. Six modern approaches. J. L. McCary. Grove Press, New York, 1959. 383 pp. $1.95.

Time's Arrow and Evolution. Harold F. Blum. Princeton Univ. Press, Princeton, N.J., ed. 2, 1959. 224 pp. $1.75.

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Reports

Propagation of Poliovirus, Measles, and Vaccinia in Guinea Pig Spleen Cell Strains

Abstract. A new mammalian cell strain was established from guinea pig spleen tissues and has shown interesting virus sensitivity. Several viruses have been successfully propagated in the cells. For one of these, poliovirus, it represents one of the two successful attempts at propagating the virus in nonprimate or nonhuman cultures.

During the course of a study on the phagocytosis of *Mycobacterium tuberculosis* in tissue culture, an attempt was made to establish a cell line derived from guinea pig spleen. Reports on the successful primary cultivation of spleen tissue have been numerous; however, to our knowledge no report of a stable cell line has been recorded. Several reticular spleen cell lines (*1*) with demonstrated phagocytic activity have been established in these laboratories.

Several investigators have attempted to propagate poliovirus in nonprimate and nonhuman cells by utilizing both primary and cell line type cultures. With but one notable exception—Sheffield and Churcher (*2*), who successfully adapted all three strains of polioviruses (*3*) to the "transformed" embryo rabbit kidney cell line (ERK-1) of Westwood *et al.* (*4*)—no additional reports have been published.

In establishing these cell lines the spleen of guinea pigs was minced and smeared on the surface of two medicine bottles. These were incubated at 37°C for 30 minutes, following which medium 199 containing 10 percent horse serum and 100 units of penicillin and 100 μg of streptomycin per milliliter was added. After 5 days' incubation, at which time patches of mixed cell types were observed, the medium was changed. After 15 days the mixed cell masses had degenerated except for several patches of reticular-type cells which covered approximately one-third of the inoculated area. At this time the concentration of horse serum in the replacement medium was increased to 40 percent. After 29 days the culture was treated with trypsin, and the resulting cell suspension was used to seed two bottles. These cultures grew well, and additional serial transfers were made. During the early stages of growth the cells appeared reticular-like. The confluent cell sheets appeared to be similar to human amnion epithelial cell line cultures. Following the 38th passage the horse serum concentration was reduced to 5 percent. The GPS-1 (*1*) culture has been carried through 56 passages.

A second cell line from guinea pig spleen (*1*), GPS-2, and a cell line from embryonic guinea pig liver have been established in a similar manner. With these cultures 10 percent horse serum was utilized from the outset. After 25 and 10 transfers, respectively, no alteration in appearance has been noted, and there is no detectable difference in the morphology of GPS-2 from that shown by GPS-1.

Submerged cell cultures of GPS-1 have been prepared and maintained on medium 199 containing 5 percent horse serum, according to the method of Cherry and Hull (*5*) as modified by Simpson and Johnson (*6*). This modification eliminates the gassing step during the initiation and maintenance of cultures. Estimates of cell populations were made by a modification (*6*) of the method of Waymouth (*7*).

Fresh cultures of the GPS-1 cells were prepared by two methods: (i) from submerged cultures by direct "planting" into medicine bottles or roller tubes, and (ii) by trypsinizing medicine bottle cultures.

Roller tube cultures were inoculated with undiluted suspensions of the three types of polioviruses (*3*) and observed at 24-hour intervals. A degree of cytopathogenic effect typical of that seen in human amnion and in trypsinized monkey kidney cultures was observed with all three virus types in less than 24 hours. The cytopathogenic effect was complete in less than 48 hours. Serial passages of the three types of viruses were made into additional GPS cultures, and the typical cytopathogenic effect was observed for six serial passages. These results are considered to be a demonstration that polioviruses can be propagated in this cell line. The same criterion was used in determining the sensitivity of the GPS-1 to other viruses. All three strains of poliovirus propagated in GPS-1 were identified by quantitative neutralization tests in trypsinized monkey kidney cultures with standard poliovirus antisera.

Measles virus was also propagated in the GPS-1 cells in the manner described above. The cytopathogenic effect is much the same as that produced in human amnion cells. The effect can be described as masses of multinucleated cells with inclusions and syncitia.

Preliminary experiments indicate that measles virus reaches a somewhat higher titer in GPS-1 cells than in human amnion cells. In addition, measles virus produced in human amnion cells seems to attain a higher titer in GPS-1 cultures than in homologous human amnion cultures.

Vaccinia virus of calf lymph origin was also grown in GPS-1 cultures. The infected cells became enlarged, rounded, and opaque, and they appeared to contain inclusions. The distinctiveness of the cytopathogenic effect in GPS-1 cells is in direct contrast to that observed in primary rabbit kidney cultures. Preliminary experiments indicate that calf lymph vaccinia virus attains higher titers in GPS-1 than in trypsinized rabbit kidney cultures.

Comparative titrations of poliovirus (*3*) produced in trypsinized monkey kidney (TMK) cultures were carried out in both trypsinized monkey kidney and

Table 1. $TCID_{50}$ titers of polioviruses grown in trypsinized monkey kidney cultures assayed in trypsinized monkey kidney and GPS-1 cells.

Negative $\log_{10}$ $TCID_{50}$ titer					
Type I		Type II		Type III	
TMK	GPS-1	TMK	GPS-1	TMK	GPS-1
		Titration #1			
7.5	7.0	7.0	6.4	6.7	6.3
		Titration #2			
7.3	6.8	7.3	6.7	6.8	6.6
		Titration #3			
7.3	7.0	7.1	6.8	7.0	6.6

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

GPS-1 cultures. Table 1 shows the results of these titrations. The results obtained demonstrate that pools of poliovirus grown in trypsinized monkey kidney cultures attained $TCID_{50}$ titers, as calculated by the method of Reed and Muench (*8*), of 0.5 log less in GPS-1 cultures than they do in trypsinized monkey kidney cultures.

A pool of type I poliovirus, Mahoney strain, was prepared from GPS-1 cultures. The cytopathogenic effect for this culture was complete in less than 24 hours. This pool was titrated three times in both trypsinized monkey kidney and GPS-1 cells. On each occasion the titer was higher in the former than in the latter. The titers obtained in trypsinized monkey kidney cell assays were of the order of those obtained when poliovirus produced in trypsinized monkey kidney is titrated in the same cells. This indicates that infective virus particle concentrations are the same when pools are grown in either culture.

The cell strain derived from embryonic guinea pig liver was found to be susceptible to infection by poliovirus. This cell line, as well as GPS-2, is being investigated for virus sensitivity. Preliminary results show that polioviruses, measles, and vaccinia grow and produce cytopathogenic effects in GPS-2 which are identical with those in GPS-1.

Heavy suspensions of GPS-1 cells in complete medium have been inoculated with and without cortisone into adult and suckling guinea pigs by several routes to determine whether or not these cells have undergone transformation to a malignant state. No gross evidence of malignancy has been observed.

Since the first report in 1957 (*2*) of the susceptibility of the nonprimate cell line ERK-1 to poliovirus, there has been considerable controversy. Some critics of the work doubt that the cell is actually of rabbit origin. It is considered a primate cell line contaminant. Some support for this stand can be drawn from the work of Melnick and Habel (*9*), who found by complement-fixation techniques that the ERK-1 cell line possessed an antigen in common with HeLa and other primate cell lines. These latter findings, however, can also be used to support the theory that many cell lines possess a common antigen which was not present in primary cells.

Though primary cell cultures may be refractory to infection by poliovirus, it is possible for cell lines when transformed to become susceptible to infection by this virus. Since primary guinea pig tissues have been found to be refractory to infection and cell lines susceptible, it would seem that some change or transformation has occurred.

In our laboratories a guinea pig embryo liver and two guinea pig spleen cell lines, all susceptible to poliovirus, have been established by the techniques described. It seems very unlikely that all three cell lines are in reality primate cell line contaminants.

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References and Notes

1. Guinea pig spleen cell lines (Stanfield #1 and #2), referred to as GPS-1 and GPS-2.
2. F. W. Sheffield and G. Churcher, *Brit. J. Exptl. Pathol.* 38, 155 (1957).
3. Poliovirus types I, II, and III used in this study were Mahoney, MEF-1, and Saukett, respectively. Stock pools of virus were prepared in trypsinized monkey kidney cultures.
4. J. C. N. Westwood, I. A. MacPherson, D. H. J. Titmuss, *Brit. J. Exptl. Pathol.* 38, 138 (1957).
5. W. Cherry and R. N. Hull, *Anat. Record* 124, 483 (1956).
6. I. S. Johnson, *Ann. N.Y. Acad. Sci.*, in press.
7. C. Waymouth, *J. Natl. Cancer Inst.* 17, 305 (1956).
8. L. J. Reed and H. Muench, *Am. J. Hyg.* 27, 493 (1938).
9. J. L. Melnick and K. Habel, *Federation Proc.* 17, 526 (1958).

17 December 1958

Role of Magnesium in Acetyl Coenzyme A Formation by Acetothiokinase

In a recent discussion (*1*) of the role of magnesium in enzyme-catalyzed reactions involving adenosine triphosphate, Ingraham and Green postulated that magnesium acts by chelating with the substrates and the enzyme in such a way that the net effect is to alter the "entropy of activation" and thereby promote the reaction. Without considering the implications of this hypothesis in the general problem of metal ion catalysis in enzymic reactions, I should like to point out that the specific hypothesis concerning the role of magnesium in acetyl coenzyme A (CoA) (*2*) formation advanced by Ingraham and Green (*1*) is in contradiction to published experimental findings.

In analyzing the sequence of events leading to the formation of acetyl CoA from ATP, acetate, and CoA (see *1*, Fig. 2), Ingraham and Green proposed that a complex is first formed between CoA, Mg^{++}, and the enzyme and that this is followed by reactions with ATP and acetate. This results in the liberation of free inorganic pyrophosphate and in the formation of acetyl AMP, linked through magnesium to the enzyme. It was proposed that in the final step of the reaction there is a transfer of the acetyl group from the magnesium-bound acetyl AMP to the sulfhydryl group of CoA.

While it is clear that Mg^{++} is required for the over-all reaction, the series of reactions proposed by Ingraham and Green (*1*) leads to certain verifiable predictions. These are (i) that CoA is required for the isotope-exchange reaction between P^{32}-labeled inorganic pyrophosphate and ATP and (ii) that Mg^{++} is required for the formation of acetyl CoA from acetyl AMP and CoA. It has already been demonstrated that the formation of acetyl CoA from ATP, acetate, and CoA (reaction 3, below) actually occurs in at least two discrete steps (reactions 1 and 2).

$$\text{ATP} + \text{acetate} \overset{Mg^{++}}{\rightleftarrows} \text{acetyl AMP} + \text{PP} \quad (1)$$

$$\text{Acetyl AMP} + \text{CoA} \rightleftarrows \text{acetyl CoA} + \text{AMP} \quad (2)$$

$$\text{ATP} + \text{acetate} + \text{CoA} \overset{Mg^{++}}{\rightleftarrows} \text{acetyl CoA} + \text{AMP} + \text{PP} \quad (3)$$

Reaction 1, which is easily measured by the acetate-dependent exchange of PP^{32} and ATP or by the conversion of acetyl AMP to ATP, requires the presence of Mg^{++}. Not only is CoA not required for this reaction but if it is added the rate of exchange is decreased (*3*). Reaction 2, which is measured by the conversion of acetyl AMP to acetyl CoA, occurs in the absence of Mg^{++}. Neither the rate nor the extent of the reaction is affected by the addition of Mg^{++}.

That this is not due to the presence of Mg^{++} in the enzyme or reactants can be inferred from the requirement for added Mg^{++} when the over-all reaction (reaction 3) is studied (*3*). The most direct interpretation of these data is that Mg^{++} is involved only in the initial step of the reaction—namely, the reaction sequence involving ATP.

It is conceivable that these conclusions can be interpreted by proposing that exogenously supplied acetyl AMP is utilized by the enzyme at some unrelated transacylating site which does not require Mg^{++} (*4*). I feel that this is probably unlikely, since the presence of acetyl AMP excludes ATP from reacting with the enzyme. This is shown by the fact that if acetyl AMP is added to the complete system (ATP, acetate, CoA, Mg^{++}, and the enzyme), acetyl CoA synthesis continues but pyrophosphate formation is decreased to approximately one-tenth the rate found in the absence of acetyl AMP. When the added acetyl AMP is exhausted, the rate of PP formation is restored to the control level (*3*). This provides evidence that acetyl AMP competes for the site occupied by ATP. Were the acetyl AMP to be used at a second site on the enzyme, one would not expect an inhibition of the reaction in which ATP is utilized.

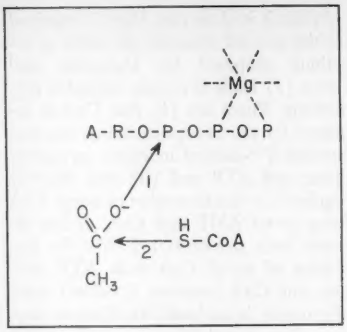

Fig. 1. Schematic representation of acetyl CoA formation on enzyme surface.

In my view the simplest hypothesis consistent with the experimental findings is that the sites necessary for enzymatic activity are specific for ATP, acetate, and CoA (Fig. 1). Magnesium may be a functional part of the specific site for ATP or, alternatively, the site may be specific for a particular ATP-Mg complex. Thus, the presence of ATP, Mg^{++}, and acetate would lead to an elimination of PP (or a dissociable Mg–PP complex) and the formation of acetyl AMP (bound to the enzyme). In the presence of CoA this would be followed by a magnesium-independent cleavage of the acetyl AMP to form acetyl CoA. On the basis of this hypothesis acetyl AMP would be expected to share, at least in part, the site with ATP.

The only enzymatic system which to my knowledge is analogous to the acetate-activating system and which has been studied in sufficient detail with respect to the magnesium requirements involves luciferin. Airth, Rhodes, and McElroy (*5*) have shown that the activation of luciferin by crystalline luciferase is markedly stimulated by Mg^{++} but that no such requirement is evident when luciferyl adenylate is the substrate either for the light-producing reaction or for the formation of luciferyl CoA (*6*).

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References and Notes

1. L. L. Ingraham and D. E. Green, *Science* 128, 310 (1958).
2. The following abbreviations have been used in this report: AMP, adenosine 5′-monophosphate; ATP, adenosine triphosphate; CoA, coenzyme A; PP, inorganic pyrophosphate.
3. P. Berg, *J. Biol. Chem.* 222, 991 (1956).
4. D. E. Green, personal communication.
5. R. L. Airth, W. C. Rhodes, W. D. McElroy, *Biochim. et Biophys. Acta* 27, 519 (1958); W. D. McElroy, personal communication.
6. The studies reported here were carried out while I was a scholar in cancer research of the American Cancer Society; they were supported by a research grant from the U.S. Public Health Service.

17 October 1958

In the report to which Berg refers we proposed a general mechanism for ATP-catalyzed enzymatic syntheses, the essence of which involves the gathering of reactants within a single enzyme-Mg complex and then a sequence of displacement reactions. By this device the term for entropy of activation becomes relatively small, and thus the principal barrier to reaction is overcome.

As a specific example of this mechanism we considered the enzyme acetokinase, which catalyzes the synthesis of acetyl CoA from acetate, ATP, and CoA only in the presence of Mg^{++}, and postulated that the Mg enzyme forms a complex with ATP and CoA and that two consecutive displacement reactions then ensue—the displacement, first, of a pyrophosphate group by acetate and second, of adenosine monophosphate by CoA. After these displacement reactions the products—acetyl CoA, adenosine monophosphate, and inorganic pyrophosphate —dissociate from the Mg-enzyme complex.

In the necessarily brief development of this hypothesis we omitted to stress (i) that the order of complex formation is not critical and (ii) that any exchange or partial reaction catalyzed by the Mg-enzyme complex does not require the presence of a ligand which does not participate in this reaction. Thus, the exchange of ATP with PP requires only acetate and not CoA, while the displacement of adenosine monophosphate in enzyme-bound acetyl AMP by CoA does not require the presence of ATP or its products of cleavage.

It appears to us that the behavior of the acetokinase system is in full accord with this hypothesis. Only a single enzyme is required for the synthesis. No intermediates formed in the reaction have been found to dissociate from the enzyme (*1*, *2*). The only recognizable components are the initial and final products. Berg (*1*) has demonstrated that synthetic acetyl AMP can give rise to acetate and ATP in the presence of inorganic pyrophosphate and Mg^{++}, and to acetyl CoA and inorganic pyrophosphate in the presence of CoA. He has not, however, been able to demonstrate that acetyl AMP is formed in any measurable amount during the over-all reaction in the presence of Mg^{++}. We take this negative result to mean that the intermediate is not acetyl AMP but the corresponding magnesium chelate, which has no measurable dissociation. We assume further that the enzyme-bound magnesium chelate of acetyl AMP can interact with CoA with the same facility as acetyl AMP added to the Mg^{++}-free enzyme. Thus, the lack of a Mg^{++} requirement for the formation of acetyl CoA from acetyl AMP has no bearing on the question whether the intermediate is free acetyl AMP or its Mg chelate. The problem is whether or not CoA can react with the Mg-chelated and enzyme-bound intermediate. There is no evidence yet available bearing on this point.

Berg raises the further objection to our hypothesis that CoASH is not required for the acetate-dependent exchange of PP^{32} and ATP, and that if added it decreases the rate of exchange. As stated above, the order of complex formation is of no importance, so the inhibition of PP^{32} exchange by CoASH is not a criterion of the validity of the proposed mechanism.

Until the ambiguities and uncertainties in the observations cited by Berg have been resolved by further decisive experiments, we find no compelling reason to revise the mechanism we have proposed for the acetokinase system.

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References

1. P. J. Berg, *J. Biol. Chem.* 222, 991 (1956).
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1 December 1958

Interaction of Gibberellic Acid and Indoleacetic Acid in Impatiens

Abstract. Gibberellic acid promotes doubling, early flowering, and fruiting directly in *Impatiens*. It also lengthens the stem, probably through a neutralization of auxin inhibitors. Such a mechanism would leave the growth-promoting auxins unchecked to produce the increased elongation characteristic of gibberellin application. It seems that application of additional auxin produces a rapid build-up of the auxin inhibitor(s) in the plant.

Though gibberellic acid has auxin-like activity in the sense that it induces cellular elongation in stem tissue, it is difficult to decide whether it should be regarded as an auxin (*1*). While working with *Impatiens balsamina* L. on the inheritance of flower doubling, I noticed that the "double" variety showed incomplete penetrance of the recessive gene p_t which is responsible for the production of double flowers (*2*). Outbreeding of highly inbred "double" strains of *Impatiens* restored full penetrance of p_t for one generation only; the F_3 generation of such an outcross again showed considerable reduction in penetrance.

To determine whether growth-pro-

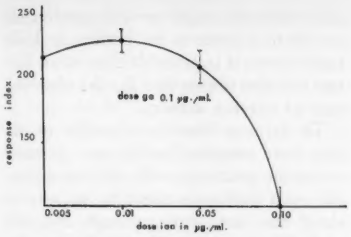

Fig. 1. Effect of different concentrations of indoleacetic acid, applied as sprays on alternate days, on plant height of *Impatiens* treated simultaneously with sprays of gibberellic acid (10^{-4} g/1000 ml), measured after 3 weeks of treatment. Height is expressed as percentage of that of untreated plants.

Table 1. Influence of growth substances on the penetrance of doubling in a progeny of a highly inbred strain of "double" *Impatiens*. Sprays (5 ml) of the growth substances in a concentration of 10^{-4} g/1000 ml were applied on alternate days from the four-leaved seedling stage until flower-bud initiation (approximately 7 weeks). Fifty plants were used per treatment. The figures in parentheses indicate the number of treatments.

Treatment	Flowers	
	Double	Single
Control (37)	32	18
Indolepropionic acid (45)	36	14
Indoleacetic acid (30)	37	13
β-Naphthoxyacetic acid (30)	30	20
α-O-Chlorophenoxy-acetic acid (30)	34	16
α-O-Chlorophenoxy-propionic acid (30)	32	18
Gibberellic acid (30)	50	
α-Naphthaleneacetic acid (30)	35	15

Table 2. Influence of combined sprays of gibberellic acid (GA) (concentration 10^{-4} g/1000 ml) and indoleacetic acid (IAA) (concentrations 5×10^{-6} to 10^{-4} g/1000 ml) on the penetration of flower doubling and flowering time of *Impatiens*.

Concn.		Double-flowering plants (%)	Flowering time* (day)
IAA	GA		
5×10^{-6}	1×10^{-4}	98	+19
1×10^{-5}	1×10^{-4}	100	+19
5×10^{-5}	1×10^{-4}	100	+21
1×10^{-4}	1×10^{-4}	100	+22
		64	

* Days prior to flowering date of control plants.

moting substances might influence this penetrance, several compounds were tested on seedlings of the highly inbred "double" ($p_t p_t$) lines. Gibberellic acid at a concentration of 10^{-4} g/1000 ml, applied as a spray in doses of 5 ml each alternate day until flowering, had the most pronounced effect. The plant treated showed full penetrance of doubling, whereas the control yielded 67 percent double-flowering individuals (33 percent flowered single). From this experiment it became evident that gibberellic acid may play an important role in the physiological requirements necessary for expression of the gene for doubling. The plants that received gibberellic acid up to flowering time flowered 3 weeks earlier than the control. The height of the treated plants was approximately 2½ times that of the average height of the controls.

Of six other growth-substances tested, none had an effectiveness approaching that of gibberellic acid (Table 1).

The seedlings that received indoleacetic acid (IAA) were slightly stunted in stature, and their flowering time was delayed by 2 weeks. Moreover, when IAA and gibberellic acid were combined, at concentrations of 10^{-4} g/1000 ml each, we noticed that the elongating effect of gibberellic acid was completely inhibited and that the treated plants grew to normal stature. These plants flowered 3 weeks ahead of the controls and showed full penetrance of doubling. To confirm this, seedlings of the same strain were treated in the same manner as before with a solution of gibberellic acid (10^{-4} g/1000 ml) plus a series of concentrations of IAA. Figure 1 illustrates the general trend of internode extension in intact plants after 3 weeks of alternate-day treatments. Relatively small amounts of IAA increased the elongating effect of gibberellic acid, but with increasing concentrations of IAA the response to gibberellic acid at a concentration of 10^{-4} g/1000 ml decreased, and at IAA concentrations of 10^{-4} g/1000 ml the elongating effect of gibberellic acid was completely nullified. On the other hand, the secondary effects of gibberellic acid, such as early flowering and increase in penetrance of doubling, were not affected by simultaneous treatment with IAA (Table 2). In general, the fertility of the treated plants was much greater than that of plants treated with gibberellic acid only.

It has been assumed that there is, in the intact plant, an inhibitory system which limits the growth rate (*3*). Growth of intact internodes is considered to be regulated by a three-factor system, consisting of auxin, an auxin inhibitor, and a hormone with physiological properties similar to those of gibberellic acid. The above results indicate that the concentration of the auxin inhibitor depends upon the concentration of auxin present. On the basis of the dose-response curve (shown in Fig. 1) it appears that the relationship between auxin concentration and auxin inhibitor production is not linear. At relative high auxin levels the production of auxin inhibitor is so greatly accelerated that there is more auxin inhibitor present in the plant tissue than there is auxin. Future biochemical studies may throw some light on these highly interesting phenomena (*4*).

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4. These investigations were supported by the University of Alberta general research grant No. 178.

4 November 1958

Drug Metabolism in the Newborn Rabbit

Abstract. A number of drugs that are metabolized through the action of enzymes present in liver microsomes in the adult rabbit are not metabolized in livers of newborn rabbits. The development of metabolic pathways during a period of 4 weeks is presented. Evidence is given for the presence in livers of baby rabbits of inhibitors of some of these drug-enzyme systems.

One of the factors that modifies the actions of drugs and that is taken into account in their therapeutic use is the age of the subject. It is known that the young, both of animals and of human beings, are more sensitive to certain drugs than the adults. This greater sensitivity could result from differences in the responsiveness of the receptors or from differences in the fate of the drug —that is, with respect to absorption, distribution, excretion, or metabolism—or from both. We chose to investigate possible differences in drug metabolism (*1*).

A variety of drugs are metabolized through the action of enzymes present in liver microsomes (*2*). The greater sensitivity to drugs of the young animal may be in part due to a deficiency of these enzymes, since other studies have shown that certain tissues, including liver, have enzyme levels which are several times higher in the adult than in the embryo (*3*). Also, electron micrographs show that differences do exist be-

tween the adult and the embryonic structures from which the microsomes are derived (*4*).

In order to gain a more general picture of the development of drug enzyme systems, various pathways were studied. These included the side-chain oxidation of hexobarbital, the N-dealkylation of Pyramidon, the deamination of amphetamine, the hydroxylation of the aromatic ring of acetanilid, the oxidation of the ring sulfur of chlorpromazine, and the reduction of the aromatic nitro- group of *p*-nitrobenzoic acid. In addition, both the homogenate, containing all the particulate matter of the cell, and the supernatant (9000*g*), containing only the microsome and soluble fractions, were used in this investigation. Table 1 presents our findings relative to six of these pathways.

Table 1. Development of drug-metabolizing enzymes in rabbit liver (*7*). For methods used in determination of metabolism, see Brodie (*2*) and others (*8*). The type of metabolism represented by each substrate is described in the text.

Preparation	Drug metabolism (μmole/g)* at age		
	2 wk	3 wk	Adult
	Hexobarbital		
Homogenate	0.96	2.8	8.4
Supernatant	4.2	10.3	16.6
	Aminopyrine		
Homogenate	0.15	0.30	3.25
Supernatant	0.34	1.41	5.2
	l-*Amphetamine*		
Homogenate	1.3	1.9	8.8
Supernatant	1.9	15.1	21.1
	Acetanilid		
Homogenate	1.0	1.9	4.5
Supernatant	2.9	5.2	7.8
	Chlorpromazine†		
Supernatant	11.4	31.5	32.3
	p-*Nitrobenzoic acid*		
Homogenate	1.72	5.16	9.9
Supernatant	1.76	5.28	8.1

* Micromoles of drug metabolized, or of metabolite formed, per gram of protein of liver fraction used. The protein was determined spectrophotometrically (*9*). Values given for the metabolism of drugs are those of typical experiments. Enzyme activities for each metabolism at each age were determined at least twice.

† In these studies chlorpromazine metabolism could not be followed satisfactorily in homogenates, due to strong binding of the drug by nuclei or mitochondria.

Table 2. Effect of cell fractions from baby rabbit liver on the metabolism of amphetamine by adult rabbit liver.

Description	Metabolism of *l*-amphetamine	
	μmole*	Inhibition (%)
Baby (homogenate)	0	
Baby (supernatant)	0	
Adult (supernatant)	3.25	
Adult (supernatant) plus baby (homogenate)	0.59	82
Adult (supernatant) plus baby (supernatant)	3.34	0

* Micromoles of amphetamine metabolized by homogenates or supernatants from 1 g of liver.

The newborn rabbit is essentially unable to metabolize any of the drugs used. When it reaches the age of 2 weeks we see an appearance of activity with respect to all pathways, though the extent of this activity is not the same in every instance; it ranges from 5 to 37 percent of the enzyme activity of adults. The 3-week-old animals seem to have even more enzyme activity, and the activity in the liver of the 4-week-old rabbit is in most cases approximately equal to that of the adult.

The apparent lack of enzyme activity in the young animal could be due to (i) an actual absence of enzyme protein; (ii) a deficiency of cofactors—that is, reduced coenzyme II [reduced triphosphopyridine nucleotide (TPNH)]; (iii) the presence of inhibitors of the drug-metabolizing enzymes; or (iv) differences in the nature of the enzymes in the livers of baby and adult rabbits—for example, differences in optimal *p*H or substrate concentrations.

We tried to eliminate the second possibility by adding a TPNH-generating system of glucose-6-phosphate, glucose-6-phosphate dehydrogenase, triphosphopyridine nucleotide (*5*), and nicotinamide in all our determinations.

The presence, in the liver of the baby rabbit of inhibitors of drug metabolism was suggested by differences in the rate of appearance of enzyme activity in homogenates as compared with the rate of appearance in the supernatant (9000*g*). For several of the pathways studied, relatively more enzyme activity seemed to be present in this latter fraction (see Table 1).

Table 2 shows that homogenates of baby rabbit liver do indeed contain some material which inhibits the metabolism of amphetamine. Inhibitors of hexobarbital, acetanilid, and Pyramidon metabolism have also been demonstrated in this type of preparation.

This inhibition is usually not seen when the supernatant (9000*g*) fraction of baby rabbit liver is used. Thus, we seem to be dealing with inhibitors present in the nuclear or mitochondrial fractions.

Also of interest is the fact that this material seems to disappear as the animal matures, at a rate inversely proportional to drug-metabolizing enzyme activity. However, since no inhibitors of *p*-nitrobenzoic acid or chlorpromazine metabolism seem to be present in baby rabbit liver, it is probable that other factors are also responsible for the observed lack of enzyme activity.

To date we have been unable to obtain liver samples having one or more metabolic pathways while lacking others. All such pathways seem to appear at about the same time, though the rate of development is different. It may be, then, that a single event triggers the synthesis or unmasking of all the enzymes (*6*).

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5. The glucose-6-phosphate, glucose-6-phosphate dehydrogenase, and triphosphopyridine nucleotide used in this study were purchased from Sigma Chemical Company, St. Louis, Mo.
6. Further studies in progress include investigation of the nature of the inhibitors described in this report; study of factors which may stimulate enzyme synthesis; changes in ultrastructure at the time of appearance of these systems; and correlation of in vitro with in vivo results.
7. The *l*-amphetamine and the chlorpromazine used in this study were kindly furnished by Dr. Glenn Ullyot of Smith, Kline & French Laboratories, Philadelphia.
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20 October 1958

Resistance to Sevin by DDT- and Parathion-Resistant Houseflies and Sesoxane as Sevin Synergist

Abstract. The new carbamate insecticide, Sevin, has a low toxicity against houseflies. However, it is activated effectively by low concentrations of Sesoxane, a pyrethrum synergist. This occurs with normal nonselected flies and also with strains selected for resistance to DDT and Parathion, which have considerable cross resistance to Sevin.

1-Naphthyl N-methyl carbamate (Sevin), a new insecticide introduced by Union Carbide Chemicals Company, shows great promise in the field because of the success it has already had in the control of many agricultural pests in the field and because of its low toxicity to mammals.

Recent investigations (*1*) on the house-

fly, *Musca domestica,* have shown that Sevin is only about one-tenth as toxic as DDT (the LD_{50} values, for topical application, are 0.2 μg per fly for DDT and 2.3 μg per fly for Sevin). In an attempt to increase the effectiveness of Sevin, several pyrethrin synergists were investigated. Of those investigated, 2-(3,4-methylenedioxyphenoxy)-3,6,9-trioxaudecane (Sesoxane), a pyrethrin synergist discovered by Beroza (*2*) and manufactured by Shulton, Inc., was most effective. This compound has been reported as having some synergistic action for methoxychlor (*3*) and was found in our laboratories to be a synergist for DDT on German roaches. When tried with DDT on houseflies, it showed little synergism. However, Sesoxane in conjunction with Sevin gave a greatly increased toxicity for houseflies. Figure 1 shows the log dose–probit lines for DDT and Sevin, with and without the synergist, for the susceptible houseflies; dosage is expressed as the logarithm of the number of micrograms applied, and mortality is expressed in probits.

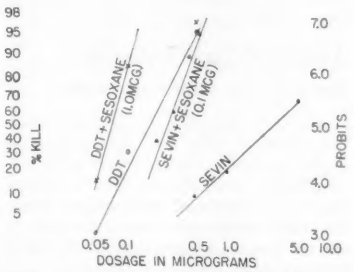

Fig. 1. Dosage mortality curves for susceptible houseflies treated with Sevin and DDT with and without Sesoxane.

Table 1. Mortality, after 24 hours, of susceptible and resistant houseflies topically treated with Sevin and Sevin-Sesoxane combinations. Twenty-five flies were treated at each point. The percentages represent the combined results of duplicate tests.

Sevin (μg/fly)	Sesoxane (μg/fly)	Kill (%)
	Susceptible	
0.5		10
1.0		20
2.0		55
5.0		67
	Parathion-resistant	
5		10
10		10
30		10
	DDT-resistant	
5		20
10		40
30		60
	Susceptible	
0.1	0.00	0
0.1	0.10	40
0.1	0.30	80
0.1	0.50	95
0.5	0.10	95
	Parathion-resistant	
1.0	0.00	0
1.0	1.00	60
1.0	5.00	100
1.0	10.00	100
	DDT-resistant	
1.0	0.00	10
1.0	0.50	100
1.0	1.00	100
1.0	5.00	100
0.1	5.00	100

Since both Sevin and Parathion are strong cholinesterase inhibitors, it may be expected that Parathion-resistant insects will also be resistant to Sevin, and this was found to be the case, as shown in Table 1. However, only a comparatively low resistance, commonly called vigor tolerance, was to be expected from DDT-resistant flies (*4*). Table 1 shows that DDT-resistant flies have about a sevenfold resistance to Sevin—that is, the LD_{50} for susceptible flies was 2.6 μg; for DDT-resistant flies, 18 μg.

Since the combination of Sevin and Sesoxane was effective on the DDT-susceptible flies, it was applied to DDT-resistant flies. This combination proved to be very effective even at small dosages. All mortalities were obtained by applying the chemicals together in acetone solutions topically to adult females. Table 1 shows the results.

The outstanding feature is the high effectiveness of the combination containing a low ratio of synergist to toxicant in contrast to the usual situation, in which large amounts of synergist are necessary.

Comparison of the rates of penetration between Sevin alone and Sevin-Sesoxane combinations shows very little difference between the two; this indicates that the effectiveness of the Sevin-Sesoxane combination is not due to increased penetration.

The effective synergistic action of Sesoxane with Sevin gives hope for control of DDT- and phosphate-resistant insects.

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23 September 1958

Multiple Hemoglobins in Fishes

Abstract. Paper electrophoregrams of the hemoglobins from 14 species of fresh- and salt-water fish demonstrated from one to three components. The relative distribution of these fractions was determined for all species. Mobilities of the three hemoglobins of rainbow trout were calculated from moving-boundary patterns. Low anodal mobility at *p*H 8.8 was characteristic of many species examined.

Since the demonstration of abnormal hemoglobin in man by Pauling *et al.* (*1*), electrophoretic studies have been carried out on many other species. The occurrence of multiple hemoglobins has been reported in other mammals (*2*), in birds (*3*), and in amphibians and reptiles (*4*). Manwell (*5*) has recently reported a difference in alkaline denaturation between adult and postlarval hemoglobins from a teleost fish (*Scorpaenichthys marmoratus*). Examination of fish hemoglobins should therefore reveal some differences which might be species characteristic and perhaps even race dependent.

Samples of fish blood were collected in heparinized tubes, either by cardiac puncture of the larger fish or by amputating the peduncle of smaller fish and collecting the droplets of blood from the severed caudal vein and artery. The red cells were separated from the plasma by centrifugation and washed three times with 0.9-percent sodium chloride. The hemoglobin solutions used for analysis (*6*) were prepared by adding 2 volumes of distilled water to 1 volume of packed red cells. After standing overnight in the cold, the hemolyzates were centrifuged at 25,000*g* for 1 hour. The supernatant

Table 1. Relative distribution of fish hemoglobin components. Values are averages from at least two fish of each species.

Electrophoregram	Percentage of total hemoglobin (%)		
	Highest mobility	Medium mobility	Lowest mobility
	Steelhead trout		
E	54–56	22–23	22–23
	Rainbow trout		
F	54–58	21–23	21–23
	Blueback salmon		
G	51–53		47–49
	Shad		
H	66–70		30–34
	Largemouthed bass		
I	60–64		36–40
	Brook trout		
J	56–64	18–22	18–22
	Silver salmon		
K	50–60		40–50
	Chinook salmon		
L	50–60		40–50

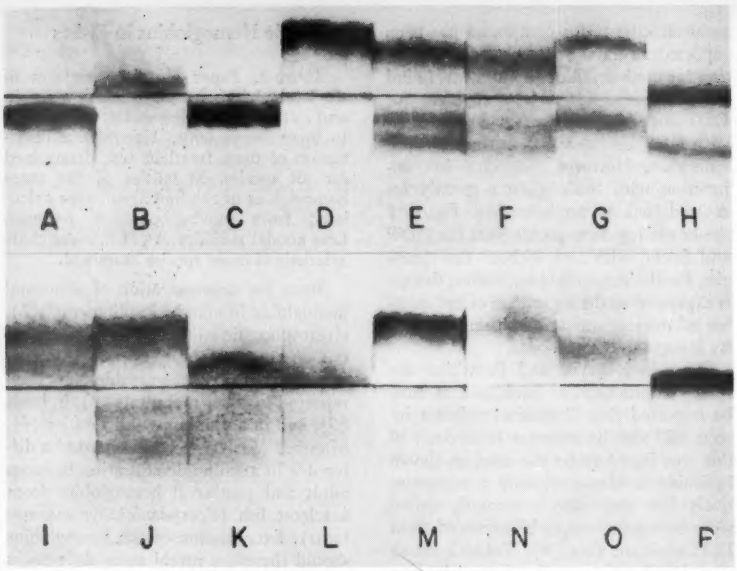

Fig. 1. Separation of fish hemoglobins in Veronal buffer (*p*H 8.8; ionic strength, 0.05): (A) *Entosphenus tridentatus* (Pacific lamprey); (B) *Lepomis macrochirus* (bluegill); (C) *Cyprinus carpio* (carp); (D) human hemoglobin A; (E) *Salmo gairdneri* (steelhead trout); (F) *S. gairdneri* (rainbow trout); (G) *Oncorhynchus nerka* (blueback salmon); (H) *Alosa sapidissma* (shad); (I) *Micropterus salmoides* (largemouthed bass); (J) *Salvelinus fontinalis* (brook trout); (K) *Oncorhynchus kisutch* (silver salmon; (L) *O. tshawytscha* (chinook salmon); (M) human hemoglobin A; (N) *Squalus acanthias* (dogfish shark); (O) *Ophiodon elongatus* (ling cod); and (P) *Ptychocheilus oregonensis* (Columbia squawfish).

fluid, after centrifugation, was stored at −10°C. Paper electrophoresis was performed in a Spinco model R apparatus at 6 ma for 6 hours; S and S 2043A paper with sodium barbital buffer (*p*H 8.8; ionic strength, 0.05) was used. Preliminary experiments had established that maximum separation occurred under these conditions. The electrophoregrams were scanned photometrically by means of a Photovolt densitometer, model 525, equipped with either a 420 or a 540 mμ filter. Moving-boundary electrophoresis of dialyzed hemoglobins was carried out at 10 ma in sodium barbital buffer (*p*H 8.6; ionic strength, 0.1) in a Perkin-Elmer model 38 apparatus operating at approximately 180 v.

In Fig. 1 the mobilities at *p*H 8.8 of hemoglobins (*7*) from 14 species of fish (*8*) are compared with that of human hemoglobin A, which served as a reference standard. Although many samples have been examined in this manner, no gross differences in mobilities have been detected in a given species with regard to sex, age, or race.

Percentage distribution of the hemoglobin, as determined by planimetry of the densitometer recordings, is given in Table 1 for those species possessing more than one hemoglobin component. In general, the largest component appears to have the highest mobility.

It is interesting to note that many fish hemoglobins are characterized by a low anodal mobility at *p*H 8.8 and are consequently shifted to the cathode side of the origin by the electroosmotic buffer flow. Mobility measurements made from moving-boundary electrophoresis patterns showed, for example, that at *p*H 8.6 the mobilities of the three hemoglobin components of rainbow trout were -2.39×10^{-5}, -1.24×10^{-5}, and -0.70×10^{-5} cm²/v sec. The low mobility at this *p*H and apparent high isoelectric point associated with many fish hemoglobin fractions may prove to be a characteristic unique among vertebrates.

Although the physiological significance of the occurrence of multiple hemoglobins in fishes is at present not known, subsequent investigation may establish a correlation of this heterogeneity with phylogeny.

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7. Preliminary studies showed no difference in mobilities of fish carbonmonoxyhemoglobin and oxyhemoglobin; consequently, all of the work described in this report was carried out with oxyhemoglobin.
8. We are indebted, for specimens, to C. H. Elling and A. Henslip, Bonneville Experimental Laboratory, North Bonneville, Wash.

26 September 1958

Analysis of Gas in Biological Fluids by Gas Chromatography

Abstract. Combining a vacuum extraction method with gas chromatography makes possible accurate, reproducible determination of small quantities of permanent gases contained in biological fluids. One useful application is demonstrated by determining the oxygen tension in 1 ml of human plasma.

Chromatography as a technique for separation of closely related substances has been known for many years. However, the more recent use by James and Martin (*1*) of gas-liquid partition chromatography has resulted in a renewed interest in the technique and the development of modern instrumentation which makes possible rapid separation and accurate quantitative analysis of most of the biologically important permanent gases when they are in the gas phase. However, it has not previously been possible to analyze the permanent gases in terms of their concentration in biological solutions, for two reasons: (i) the columns used for separation of permanent gases are adsorption columns and lose their useful characteristics when they are wet, and (ii) attempts to rapidly volatilize gases in biological solutions have been unsuccessful because of the coagulation of protein and because of the oxidation and the resultant change in gas concentrations which occur with heat. These problems have been solved by combining a vacuum extraction method with the technique of gas chromatography.

The instrumentation and apparatus consist of a gas chromatograph (*2*), a 1-mv, 1-sec full-scale strip-chart recorder (*3*), and a Van Slyke volumetric extraction chamber (*4*), the waste arm of which is connected to the carrier-gas stream of the gas chromatograph proximal to the chromatograph column. Helium is used as the carrier gas.

An aliquot of the fluid is admitted to the Van Slyke reaction chamber via a between-line Van Slyke pipette and washed in with mercury. The upper three-way stopcock is closed, the lower

stopcock is opened to the mercury reservoir, a vacuum is produced by lowering the mercury to the 50-ml mark, and the gases are extracted by gentle shaking for 2 to 3 minutes. The fluid sample is then drawn into the reservoir chamber; following this, mercury is admitted to the reaction chamber from the mercury reservoir. When the mercury level reaches the 0.2-ml mark in the reaction chamber, the upper three-way stopcock is opened to the waste-arm side and the extracted gases are injected into the carrier-gas stream by moving the fluid level to the junction of the waste arm and carrier-gas tubing. After a wait of 5 seconds, the small amount of fluid and mercury can be returned to the reaction chamber; this is closed off from the column gas, and the sample is reextracted to remove any gas that may have redissolved as the vacuum was released following the first extraction. The sample fluid is removed from the Van Slyke chamber, via the same port through which it was admitted, by filling the reaction chamber with mercury from the reservoir.

The sample gases thus placed in the carrier-gas stream are then carried through the chromatograph column and eluted as separate components; the length of time required depends upon the characteristics of the gas and the column material. Each component is detected, and the quantity of the gas present is determined by a thermal conductivity reference and by sensing cells; the signals are amplified and recorded, in time, on the strip chart recorder.

The use of a 4-ft, 5-A molecular sieve column 0.25 in. in diameter allows the oxygen component of a sample of permanent gases to be eluted first from the column; this is followed by nitrogen and carbon monoxide. Carbon dioxide is permanently absorbed. All permanent gases with the exception of argon, which at present cannot be separated from oxygen by known column materials, can be separated and analyzed by means of a molecular sieve column, a silica gel column, or a charcoal and firebrick column (*5*).

The stability of the instrumentation, including the molecular sieve column, was tested by repeated injections, over a 4-hour period, of a constant volume and concentration of oxygen and nitrogen in the gas phase through an injection port placed in the carrier-gas stream. Reproducibility of the extraction technique for oxygen was determined by analyzing the amount of oxygen contained in 1 ml of sterile distilled water which had been equilibrated at 37°C with the oxygen and nitrogen in room air. A syringe tonometer and a constant-temperature water bath were used for the equilibration. Double extraction analyses were performed on each of 35 samples over a 2-day period. The application of the technique to biological fluids was tested in the same way, human blood plasma being substituted for water. The results of these determinations are shown in Table 1.

Table 1. Oxygen tension of water and plasma as determined by gas chromatography. Column, 4-ft. 5A molecular sieve; current, 360 ma; flow pressure, 20 lb/in.^{2}; carrier gas, helium; column temperature, 100°C for water and 70°C for air and plasma. Standard deviations are given in columns 4 and 6.

Type	Sample		Peak height (mm)	O_2 (ml)	P_{O_2} (mm-Hg)
	No.	Size (ml)			
Room air	15	0.03	122 ± 0.17	.0059	140
Water	35	1.0	124 ± 0.23		148 ± 0.28
Plasma	27	1.0	92 ± 1.04	.0044	148 ± 1.68
Plasma (duplicate analysis)	13	1.0	92 ± 0.70	.0044	148 ± 1.13

The accuracy of oxygen analysis has been tested in two ways. First, both water and plasma have been equilibrated with different concentrations of oxygen, and the graphic plots of the resulting peak heights relative to the oxygen contents form a precise straight line through zero. Second, equal amounts of oxygen, whether initially in solution or initially in the gas phase, produce the same peak heights.

The extraction method presents two difficulties. (i) Biological fluids tend to foam and trap gas bubbles with vacuum extraction of gases. It is possible to collapse the bubbles, however, by pulling them through the lower stopcock before the vacuum is released. (ii) The peak heights of the oxygen curve may vary considerably if the rate of injection of the extracted gas into the carrier stream is varied (a very little practice allows one to keep this injection rate steady). However, the area under curves distorted by variable injection rates is constant. Mechanical integration of the strip chart record can remove this variable if it is so desired.

In addition to the exceptionally good stability, linearity, and reproducibility of this method, it is useful because of its accuracy and speed. The time required to introduce the plasma sample in the carrier-gas stream is less than 5 minutes. The time required for elution from the column is less than 2 minutes, and during this time another sample can be extracted.

The remarkable sensitivity of the instrumentation to minute changes in oxygen content in relatively small samples of biological fluids, the excellent stability of the instrumentation, and the accuracy of the method offer opportunity for its widespread use in biological research and clinical medicine. The method makes possible accurate analysis, on small samples, of the concentration of biologically important gases present, or changing in time, in biological solutions. It seems likely that many determinations previously made by means of the Van Slyke, Haldane, Scholander, and Warburg methods can now be made with equal or better accuracy and simplicity and in less time. The oxygen tension of arterial blood can easily be calculated from the oxygen content of plasma as determined in this manner. Such determinations previously required exceptional technical skill and even then were less accurate and more time-consuming than determinations made according to the method described (*6*).

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5. The three columns are Beckman columns No. 17298, 70019, and 70028, respectively.
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30 December 1958

Tritium Tracer in Arctic Problems

Abstract. Tritium measurements in the Arctic Ocean confirm a marked near-surface stratification. Sea water at 400 meters' depth, however, is less than 3 years old, suggesting a contribution to this water mass due to sinking along the continental shelf. The top ice layer on the Ward Hunt Island ice field is older than 25 years.

Tritium (H^3; half life, 12.26 years) is ideally suited as a natural tracer in the study of polar mechanisms of exchange and mixing among the various phases of H_2O. A steady state of cosmic-ray produced tritium has probably been achieved. Recently, however, water of relatively high specific activity has been introduced into the atmosphere by ther-

monuclear weapon tests; this water makes it possible to study short-term mechanisms of mixing in sea water and arctic ice.

As part of a study at T-3, an ice island floating in the arctic sea (*1*), three sea water samples were collected in July 1955 at depths of 10, 80, and 400 m by A. P. Crary and N. Goldstein (Air Force Cambridge Research Center). The first two samples were taken at latitude 83°00′N, longitude 92°00′W and the last at latitude 82°45′N, longitude 93°30′W. The samples were intended to represent the surface water, an intermediate water, and water of Atlantic Ocean origin, respectively.

Table 1. Tritium content of arctic samples.

Date	Lat. °N	Long. °W	Type	Depth of sea samples (m)	Temp.* (°C)	Salinity* (‰)	T:H ratio† ($\times 10^{18}$)
1 July 1955	83°00′	92°00′	Sea water	10	−1.72	31.64	6.8 ± 0.7
1 July 1955	83°00′	92°00′	Sea water	80	−1.43	32.40	0.1 ± 0.1
12 July 1955	82°45′	93°30′	Sea water	400	+0.35	34.89	0.9 ± 0.1
July 1955	About as above		Sea ice				4.0 ± 0.4
21 Oct. 1954	Ward Hunt Island		Field ice				2.2 ± 0.2
1953	North Atlantic Surface sea water (av.)						1.0 ± 0.2

* Interpolated from Project Icicle data (*5*). † A blank value of $(0.3 \pm 0.1) \times 10^{-18}$ was subtracted from all values. The values have also been corrected for decay back to time of collection.

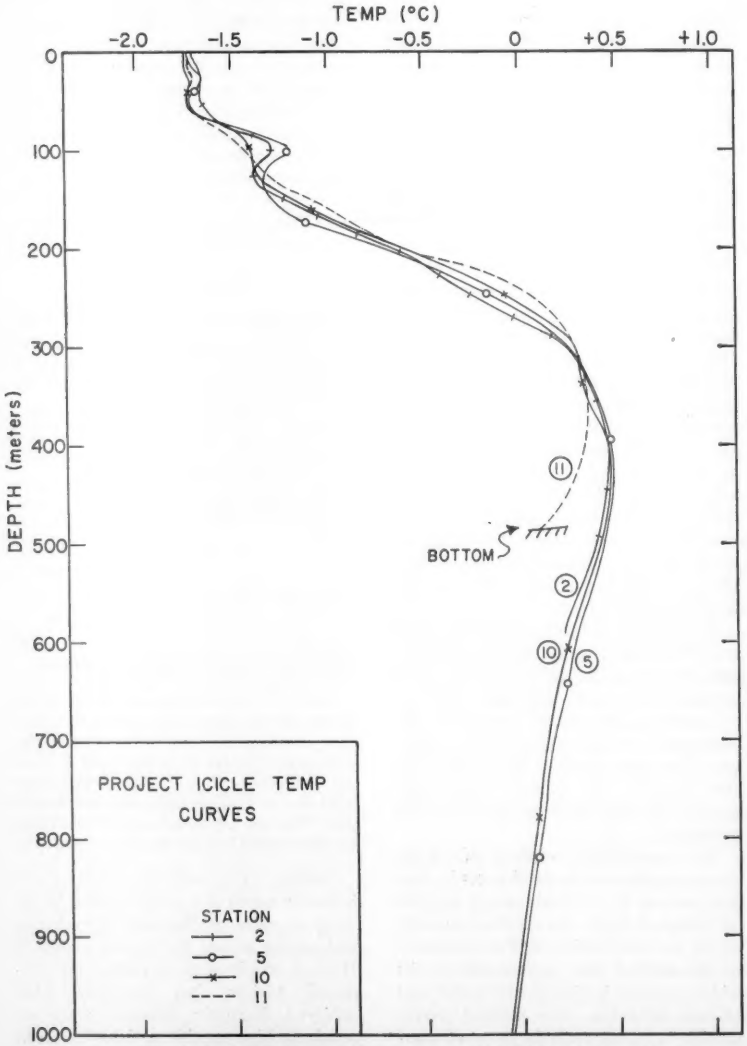

Fig. 1. Project Icicle temperature curves (after Worthington, *6*).

The 1954 atomic tests in the Pacific Ocean (Castle series) increased the tritium content of precipitation markedly in the Northern Hemisphere (*2, 3*). Therefore it would be expected that this low-salinity water would run off T-3 and reside as shallow "pools" near the surface of the sea. The surface sample of North Polar water had a relatively high tritium concentration (Table 1), 6.8±0.7 TU (tritium units = $H^3:H \times 10^{18}$). This sample, plus the two reported by Brown and Grummitt (*4*) (3.0 and 4.2 TU) suggests that the tritium content of the arctic surface water has been significantly increased by man-produced sources. The average pre-bomb North Atlantic surface water had 1.0 TU (*2*), and it is unlikely that the pre-bomb North Polar water was higher in tritium concentration, for tritium is produced largely in the stratosphere and enters the troposphere in the temperate latitudes. By the summer of 1955 North Atlantic surface water had been contaminated to the level of 2.0 to 2.5 TU (*2*). The North Polar water therefore must include melted snow of the previous year.

The sample from 80-m depth represents intermediate water which gives the sharp minor temperature maximum at about 100 m (Fig. 1). This feature was observed over a large area north of Alaska and Canada (*5, 6*). The negligible tritium content, 0.1 ± 0.1 TU (Table 1) is further evidence of the strong near-surface stratification which prevents rapid vertical mixing to 80-m depth.

The sample from 400-m depth was taken as representing Atlantic water. The overall circulation pattern (*7*) consists of inflow at the surface north of Spitsbergen, sinking of this more saline water below the arctic surface water, and counterclockwise flow along the Siberian coast and back around to the east side of Greenland. The sample from 400-m depth was collected in the small clockwise eddy which exists north of Alaska and Canada (*6*). Eighteen hydrographic stations in this general area (*5, 6*) give curves like the solid lines shown in Fig. 1 except for the water near the sample location (one station), where the temperature is considerably lower (dashed line). (The accuracy of these measurements is ±0.01°C.) It is suggested, therefore, that this water resulted from conditions in the sounds of the Canadian archipelago similar to those in the Weddell (*7*) and Chuckchi

seas (*8*) (that is, surface water freezes, adds salt to the water immediately below, which becomes more dense and sinks). In this case the amount of water is small and affects only the bottom 100 m. This sinking water mixes with the normal Atlantic-derived water but, being surface water, has a much higher tritium content. If the sample (0.9 ± 0.1 TU) were largely arctic surface water it could not have flowed down earlier than 1953 and still retain a tritium content of 0.9 TU. A similar age limitation would apply to the sample if it were Atlantic-derived, requiring improbably rapid subsurface flow rates in the arctic sea of about 10 cm/sec (if a path length of 3500 miles and 2 years' travel time are assumed). It is suggested that the water represented by this sample moved down along the continental shelf during 1953–55.

A sample of sea ice was also taken in the vicinity of the sea water samples. The loose snow cover was removed first, and only solid ice was taken. The high value of 4.0 ± 0.4 TU shows that precipitation as well as sea water forms part of the ice. Since surface snow melts in the summer, it is likely that some contamination occurs from seepage through the ice. This means that the dating of sea ice with tritium alone is, at best, a difficult problem.

A sample of ice from the Ward Hunt Island ice field (north of Ellesmere Island) collected in August 1954 had 2.2 ± 0.2 TU. Because of the results obtained from the sample of the sea ice, seepage and contamination are suspected here too. On the basis of a mean of 8 TU for precipitation (*9, 10*) in the prebomb era, it is estimated that the sample is at least 25 years old. If contamination had occurred in the summer of 1954 when precipitation probably had up to 100 TU, 2 percent of this would suffice to give the observed result on old ice containing negligible tritium. For 1953 precipitation (pre-Castle) to produce such an effect 25 percent replacement is required.

From the preceding it is seen that (i) tritium exists in measurable quantities in the ice and sea waters of the arctic; (ii) there is clear evidence of artificially produced tritium in the arctic surface sea water; (iii) the near-surface stratification of the polar sea water is confirmed; (iv) a new source of the deeper water of the Arctic Ocean was found to be in the Canadian archipelago; (v) downward seepage in arctic ice may make the dating of pack ice difficult; (vi) ice from the top of the Ward Hunt Island is at least 25 years old (*11*).

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Comparison of the Effects of Delayed Auditory Feedback on Speech and Key Tapping

Abstract. Delaying the return of a speaker's vocal output to his ears (the auditory feedback) radically changes his speech (*1*). The present report concerns the effect of delayed auditory feedback on simple key-tapping tasks. Evidence is presented which indicates that changes in speech and key tapping under delayed auditory feedback are analogous.

When a delay is instituted in the return of a speaker's vocal output to his ears (*1*), his speech changes in characteristic ways (*2*). The most common changes which occur are an increase in mean vocal intensity, an increase in phonation time, and a tendency to repeat sounds. There is considerable individual variation in the degree to which subjects manifest these changes while speaking under delayed auditory feedback conditions; however, almost all subjects show one or more of the above changes to some degree.

Preliminary studies on the effects of delayed auditory feedback on nonvocal motor tasks (*3*) have indicated that whistling and playing musical instruments are strongly influenced by delayed auditory feedback. Simple hand-clapping behavior is also reported to change under such conditions. A subject was asked to clap his hands six times as regularly as possible each time a click from a metrotome was presented through his earphones. When a delay of 250 msec was introduced in the return of the sounds of his clapping to a subject's earphones, he often clapped seven times instead of six and slowed down his performance.

It is not clear from the above data how closely the quantitative changes in nonvocal motor performances under delayed auditory feedback approximate the characteristic changes in speech under such conditions. Clarification of this issue is the rationale for our investigation (*4*).

Each of 14 young adult subjects was asked to repeat the speech sound "b" as in *book* in groups of three. During the first trial the subject's vocal output was amplified and returned without delay to his earphones. In the second trial a delay of 244 msec was introduced before the amplified speech was returned. Vocal performance was recorded on magnetic tape and later displayed on an oscilloscope and photographed. The resulting oscillograms give a graphic display of the subject's speech with respect to time and amplitude. Analysis of the oscillograms (Fig. 1, *A*) revealed that under delayed auditory feedback, subjects tended to speak louder (12 subjects), prolong sounds (eight subjects), increase pauses between sounds (11 subjects), and repeat the sound four times instead of three (eight subjects). Thirteen of the 14 subjects showed at least one of these changes.

Each of the subjects was then asked to tap on a key, the taps to be in groups of three. Each time a subject tapped the key, the lever hit a strip of spring steel with a strain gage mounted on it. During the first trial the sound produced was amplified and returned without delay to a subject's earphones (*5*). In the second trial a delay of 244 msec was introduced before the amplified sound was returned to his earphones. The amplification of auditory feedback for all conditions of the speech and key-tapping experiments was identical.

Each time a subject tapped the key, the output of the strain gage was amplified and fed into a direct-writing galvanometer to give a continuous record of the time and pressure characteristics of the subject's key tapping. Examination of the graphic records (Fig. 1, *B*) revealed that, under delayed auditory feedback, subjects tended to tap the key harder (12 subjects), hold down the key longer (five subjects), increase the pauses between taps (13 subjects), and tap four times instead of three (two subjects). All subjects showed at least one of the above changes (*6*). Thus, the changes that are observed in vocal performance under delayed auditory feedback are also observed in nonvocal performance under such conditions.

The change in speech and key-tapping performance following alteration in auditory feedback suggests that these two motor systems require auditory feedback for their control. However, the specific way in which the auditory feedback was altered—the delay in time—may be of even greater importance in explaining

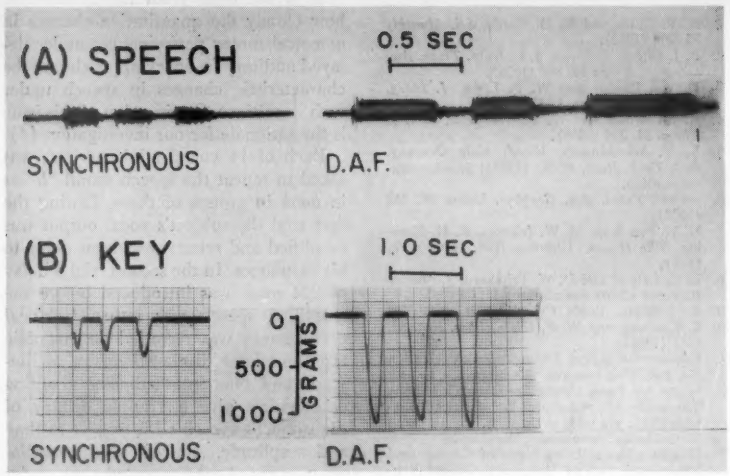

Fig. 1. (A) Oscillograms of a group of three articulations of the speech sound "b." The height of each sound display is proportional to vocal intensity. Under delayed auditory feedback, increases occur in vocal intensity, in phonation time, and in the time between sounds. Errors in number are not shown. (B) Display of amplitude and time characteristics of a group of three taps on a key. The downward displacement from the base line is proportional to the pressure exerted on the key by the subject. Under delayed auditory feedback, increases occur in pressure, in the time the key is held down, and in the time between taps. Errors in number are not shown.

the observed changes in motor performance than the fact that auditory feedback per se was interfered with. The fact that such marked changes followed a delay in auditory feedback indicates that there are critical time periods within which the sensory feedback accompaniments of a motor operation must be received to insure optimal motor control. Exceeding such critical time periods for auditory feedback is probably more disorganizing with respect to the motor operations studied than removal of auditory feedback altogether. More generally, it is possible that similar temporal alterations in sensory feedback may have similar effects on widely divergent motor functions. The parallel nature of the changes in speech and key tapping following the same delay in auditory feedback is consonant with this idea.

Performance under delayed auditory feedback probably also reflects mechanisms operating to restore control of a disordered motor function. Types of sensory feedback other than auditory—for example, tactile and proprioceptive—function in both speech and key tapping. It is possible that the increased amplitude characteristics of speech and key tapping under delayed auditory feedback operate to increase the amount of sensory feedback returning along undisturbed channels. The similarity of the changes in speech and key tapping with delayed auditory feedback may indicate that similar mechanisms operate to restore control in widely divergent motor systems.

The fact that key-tapping behavior can be so radically altered by delaying the auditory feedback of clicks raises the question of the usefulness of this technique in clinical audiometry. Presumably, the patient with psychogenic deafness, or the malingerer, would show the described changes in key tapping if he heard the delayed clicks. We are also exploring this application of our findings.

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1. Delayed auditory feedback is obtained through some simple modifications of standard tape recorders. See G. Fairbanks and R. Jaeger, *J. Speech and Hearing Disorders* 16, 162 (1951).
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5. A lack of linearity in the relationship between the pressure of a tap and the intensity of sound produced makes the parallel with the speech experiment incomplete. In the speech experiment the intensity of the auditory feedback is directly proportional to the intensity of speech.
6. It should be noted that under delayed auditory feedback an occasional subject measurably *decreased* the time he held down the key and measurably *decreased* the time between taps. Similar observations were made for speech.

28 October 1958

Great Basin Petroglyphs and Prehistoric Game Trails

Abstract. Aboriginal petroglyphs ("rock-writing") in western and central Nevada have, up to now, remained a puzzle to archeologists as regards their function and location. Recent field investigation strongly suggests that these are connected with hunting magic, presumably aimed at success in the chase, and that they are located along routes of deer migration.

In the summer of 1958, assisted by Albert B. Elsasser and Eugene R. Prince, we carried out archeological reconnaissance in northern and central Nevada (*1*). Among the types of sites studied were those at which the primary evidence of activity of man takes the form of geometric and naturalistic designs pecked into boulder and cliff surfaces. These designs, called petroglyphs (*2*), occur in greatest quantity in North America west of the Rockies. (*3*).

Despite the numerous sites known, and studies made of western North American petroglyphs (*4, 5*), there is no evidence thus far presented which satisfactorily accounts for the occurrence of petroglyphs at certain locations. Cain's conclusion (*4*, p. 54) that "all such aboriginal carvings . . . were simply a medium for expressing some emotion over a spiritual or concrete event" is typical in its vagueness and points up the failure of students of the subject thus far to arrive at specific functional conclusions.

Our recent field observations show that in western and central Nevada nearly all petroglyphs occur along deer migration trails, at spots where the animals could be shot with bow and arrow. The petroglyph designs are therefore to be understood as evidence of the practice of compulsive magic by hunters, aimed at insuring success in the chase (*6*). From several deer hunters and state and federal wildlife service field men who have studied local deer migrations, we learned in detail of a number of routes which deer follow. In the late fall, when snow starts to fall, the deer follow these routes out of the high mountains into lower country, where they winter. The deer return by these routes to higher elevations as the snow melts.

At certain points, especially at the mouths or along the courses of washes or canyons through which the deer travel, are locations which are ideal for hunting from ambush. Thus, where a wash has cut through a rock reef and the canyon narrows to form a chute or gate, or where a canyon is narrow with a boulder-strewn bench perched above the defile, or in a saddle or pass, the moving animals (particularly if driven from the rear) could be forced to run past concealed archers. Preferred hunters' positions appear to have been at those spots where the ani-

mals could be shot from above at very close range. It is at such locations that one finds petroglyphs in western and central Nevada, and a long migration trail which crosses a series of valley floors and low mountain ranges has such hunting sites (and petroglyphs) scattered along it at appropriate points.

Where deer, in moving downward to snow-free elevations, remained in the same mountain range, such sites are either correlated with some other circumstance or are absent entirely. Thus, in arid valleys petroglyphs may be found in the close vicinity of a water tank or spring. Here the purpose was apparently to aid in the taking of such animals (perhaps antelope) as came to the spot to drink.

Where deer herds are abundant, as in westernmost Nevada where the animals move east to lower country from the high eastern ranges of the Sierra Nevada mountains, petroglyph sites are most abundant; this quantitative factor may be construed as an indication of the amount of game, the density of human population, and the intensity of hunting. Other petroglyph sites occur along such major streams as the Walker, Carson, and Truckee rivers, which rise east of the crest of the Sierra Nevadas and flow out to empty into the saline lakes of the western Great Basin. The narrow flood plains of these streams served as migration trails, and petroglyphs are found at certain points where the deer had no alternative but to pass through a bottleneck. Often at such sites blinds made by piling up a circle of rocks to a height of 2 or 3 feet are found.

The authorship of petroglyphs is a difficult matter to settle. Our evidence shows that petroglyphs were made over a long period of time, since at most sites designs show not only stylistic variety but also great variation in weathering or accumulation of desert varnish, some elements appearing very fresh and others being nearly indistinguishable from the deep chocolate-hued, patinated surface of the basaltic rock. Evidence from archeology and linguistics agrees in showing that the Northern Paiute of western Nevada are relatively recent occupants of the area. The Northern Paiute, and, in fact, all of the recent tribes of the Great Basin, deny that they or their ancestors made petroglyphs. We have, accordingly, some basis for believing that petroglyphs can be attributed to the groups which occupied the area before the Northern Paiute appeared on the scene some time within the last thousand years, though at the same time cultural loss in late prehistoric times among the recent Shoshonean tribes cannot be ruled out.

As to whether the hunter himself or the shaman (medicine man) made the petroglyphs, we incline to the probability that the designs were inscribed by the shaman. Petroglyphs as hunting magic are unknown to the recent Basin tribes, but shamanistic rituals connected with the deer, antelope, or mountain sheep hunt is a widespread Basin practice. If individual hunters made petroglyphs, we should expect to find them randomly distributed and occurring at spots where a hunter was trying to cause game to appear, but this situation clearly does not square with the observed occurrence of petroglyphs. On the whole it appears probable that the ambush hunt for deer or antelope during the seasonal migrations of these animals was in earlier times in the western Great Basin a special type of hunt carried out at traditional spots by a group which was aided by the local shaman.

The fact of great numerical concentration of petroglyph symbols at particular sites, taken together with the clear indication that these designs represent an accumulation, presumably by annual increments, suggests that these hunting spots were traditional. In terms of the aboriginal way of life in the Great Basin, these evidences appear to point to a form of territorial ownership and use like that described by Omer Stewart for the Northern Paiute where groups returned year after year to the same spot to hunt or gather some variety of food. It may be proposed, further, that once a hunting site at which petroglyphs were made came into use, continued success at the spot where petroglyphs were a visible and permanent feature would tend to invest the site with magical power and efficacy which would further enhance its attractiveness as a place for successful hunting. Sites with few petroglyph designs may, therefore, be spots where the hunt was rarely successful, and sites with an abundance of designs may mark important and repeatedly used spots. Our impression is that the Indians took care not to overhunt the deer, as evidenced by the distance separating ambush sites. Overhunting along the trail might cause the animals to seek new routes and perhaps thus become available to another hunting group.

Occupational debris does not occur at most petroglyph sites, partly for the obvious reason that such spots were unfavorable for settlement. Where petroglyphs are found in immediate association with living refuse the latter appears either to postdate the petroglyphs or to be a winter village site which would have been occupied only during the period between the fall deer migration to lower elevations and the return migration in the spring to high country.

Many details of this whole matter remain to be worked out. Among these are the determination of how widespread in western North America was the practice of petroglyphic hunting magic connected with the taking of migratory deer; whether there are known major deer trails which do not have petroglyph sites along their courses; whether there are extended lines of sites which presumably mark former migration trails but which are not recorded as used in the historic period by game; what types of migratory animals were hunted in this manner (*7*); and the dating of petroglyph sites (*8*).

For determining the route of migratory game animals in prehistoric times it is also possible that ancient trails could be identified from air photographs, as was suggested by Crawford (*9*). This method could, however, be applied only in areas where plant cover was more abundant and varied than it is in the arid Great Basin region.

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1. Support for the research reported here was provided by the National Science Foundation (G3916). The cooperation of the Nevada State Museum, through its director, J. W. Calhoun, is gratefully acknowledged.
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6. We cannot, at this point, even guess whether (among others) the hope of the petroglyph author was to increase his chances for a successful arrow aim, or to compel the deer to make their appearance.
7. B. M. Hazeltine, manager of the Sheldon Antelope Refuge in northeastern Nevada, has supplied detailed information on antelope migrations. The trails in this area correlate in every particular with the occurrence of petroglyphs as given in this paper for deer. At the extensive site near Grimes, southeast of Fallon, Nev., probability favors antelope as the animal hunted rather than deer.
8. A paper describing the evidence now in hand on these subjects is in preparation. We have data on petroglyphs from about 150 sites in Nevada.
9. O. G. S. Crawford, *Archaeology in the Field* (Praeger, New York, 1953), pp. 60–62, 214, plate 5a–b.

22 December 1958

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Recently, in the largest radioactive tracer study ever conducted in the United States, NSEC successfully traced the dispersion of sewage effluent flowing into ocean waters. Our study helped the City of Los Angeles in planning expansion of its sewage system. First we injected the isotope scandium-46 into sewage about to be released into Santa Monica Bay. This enabled us to measure the pattern of sewage diffusion and its dilution in sea water to one part in ten thousand.

Write for a copy of "Radioactive Tracer Study of Sewage Field in Santa Monica Bay" by Dr. Ralph L. Ely, Jr. (He's our Vice President and Technical Director.) Or ask about our forthcoming study for the Republic of Venezuela, in which we will investigate littoral drift, using radioactive sand, to determine the feasibility of a certain harbor location.

RADIATION SICKNESS

It's common knowledge that excessive radiation produces harmful effects in human beings, ranging from mild nausea or skin burns to cancer and death. Recent experiments under the direction of Dr. A. Edelmann, Manager of our Department of Biology and Medicine, have indicated that radiation can also produce a toxic factor which appears in the blood. Analysis of the blood of rats subjected to X-rays under varying conditions not only indicates that a toxic element is produced but that it may be transferred by injection from one animal to another.

When and if this toxic substance is identified, it may be possible to devise an antitoxin to alleviate some of the effects of atomic radiation. *Medical and pharmaceutical applications of controlled radioactivity open up entirely new means of studying existing problems. Contact Dr. Edelmann about your problem.*

DETERMINATION OF BORON IN SILICON

A major problem plaguing the electronics industry is achieving ultra-pure silicon for transistors. Current methods are slow and costly, but effective. Nevertheless, boron still remains as a damaging impurity even in minute quantities of only a few parts per billion. Ordinary chemical methods cannot detect the presence of boron in such small concentrations.

However, NSEC scientists are now perfecting a process by which the boron is transmuted into radioactive carbon-11 and subsequently measured by its radioactivity.

This new method of analysis will be helpful in the quality control of silicon during production. *Once a routine method is established it will be offered on a commercial basis. Interested? Drop us a letter.*

We'll be glad to furnish detailed information on any of these studies. And if you'd like to keep abreast of new developments in the field, just ask us to put you on the mailing list for our monthly publication "Radioactivity at Work."

Our expanding business requires additional qualified technical personnel. Interested? Submit resume to Personnel Manager.

Nuclear Science and Engineering Corporation

DEPT. S-4, P. O. BOX 10901, PITTSBURGH 36, PENNSYLVANIA

Meetings

Space Science

Astronomers have for a long time known that interplanetary space is not completely empty and that the skies are not as still and serene as they seem to the poet. It comes as an exciting revelation of the first few satellites and rocket flights that space is filled with dynamic physical and chemical phenomena, some of which had not been accessible to direct observation. Physical phenomena found in space, the principles of rocketry, space biology, and space medicine were discussed in detail at a symposium held in San Antonio, Tex., on 10–12 November 1958. The symposium, the 2nd International Symposium on the Physics and Medicine of the Atmosphere and Space, was sponsored by the School of Aviation Medicine of the U.S. Air Force University. The staff of the Southwest Research Institute was responsible for the arrangements and will also edit the papers, which are to be published in book form. Over 600 scientists and many scientific leaders of government agencies attended the 42 invited presentations.

Otis O. Benson, Jr., introduced the symposium, on the note that physical and biological sciences must work hand in hand in the conquest of space. The discussions may be divided into the following categories: (i) interplanetary physics and chemistry: pressure, temperature, and chemistry of the interplanetary space; electromagnetic and ionization properties of interstellar matter; meteorites and cosmic rays; (ii) factors in space of importance to biology and medicine: gravitational environment, acceleration and weightlessness; biological effects of primary and secondary cosmic rays; time and the relativity theory; (iii) satellite physics and engineering: methods and limitations of chemical and nuclear rocket propulsion; problems in launching, tracking and reentry; manned orbital and lunar vehicles and the "rocket booster glider"; (iv) human factors: the ecology and physiology of sealed cabins; gas exchange, photosynthesis, metabolism, limits of perception, stress and adaptation, psychological problems; human tolerance to acceleration, weightlessness, vibration, temperature, and radiation; (v) problems of escape and rescue in space operations; (vi) solar and planetary environments: physics of the solar, lunar, and planetary surfaces; the possibility of life on planets and survival of living cells under simulated Martian conditions.

An intense new component of cosmic radiation was discovered from data provided by Explorer I by James Van Allen and his group, working at the University

of Iowa. This radiation is most intense above the magnetic equator and is much less intense near the poles. The radiation appears to consist of two belts of charged particles, trapped by the magnetic field of the earth, which form a giant magnetic bottle akin to those which are being studied in the laboratory for hydrogen fusion. The charged particles, electrons or protons or both, spiral around the magnetic lines of force and seem to be accelerated to considerable energies. The new component is first found at an altitude of about 600 kilometers, where the particle flux starts to increase by a factor of about two for each 100 kilometers of altitude. Its maximum intensity is reached at about two and one-half earth radii (about 16,000 kilometers), where the dose is as much as 3 to 5 roentgens per hour. At ten earth radii the dose rate drops to 0.2 roentgen per hour.

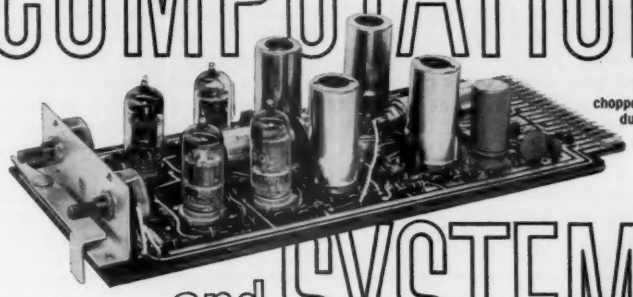
Several physicists have given theoretical explanations for the radiation belt. According to the model of S. Fred Singer of the University of Maryland, the primary cosmic-ray particles, high-energy protons, helium ions, and light nuclei are responsible for maintaining the radiation level. Near the top of the atmosphere the primaries undergo inelastic collisions. Some of the neutrons are thermalized and escape. Eventually these decay into protons, electrons, and neutrinos. It is assumed that the charged products of neutron decay make up at least part of the radiation belt.

Another explanation is that the particles possibly originate in the sun and travel in ionized magnetic clouds. When these clouds collide with the magnetic field of the earth, exchange of the particles can take place. Crucial to these theories are observations of energy, time, and spatial variation of the rays; additional data are being obtained.

The heavy-ion primaries, which we have known since their discovery by the Minnesota cosmic ray group about 10 years ago, were discussed by Herman J. Schaefer of Pensacola, Fla. The intensity of these particles is low, but they produce very heavy ionization tracks unlike those known to radiobiologists. The heavy-ion primaries are associated with solar events, and it is anticipated that during large solar flares there may be as much as a 1000-fold increase in the low-energy end of the spectrum.

It is fortunate that some knowledge already exists, from work at the 184-inch cyclotron of the Lawrence Radiation Laboratory, about the nature and severity of biological effects of high-energy protons, deuterons, and alpha particles. In addition, there are new heavy-ion linear accelerators both at Berkeley and at Yale University that have accelerated beams of several heavier ions with about 10-Mev energy per nucleon. Some biological studies on unicellular organisms

COMPUTATION



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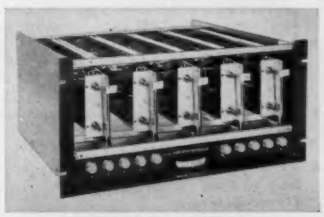

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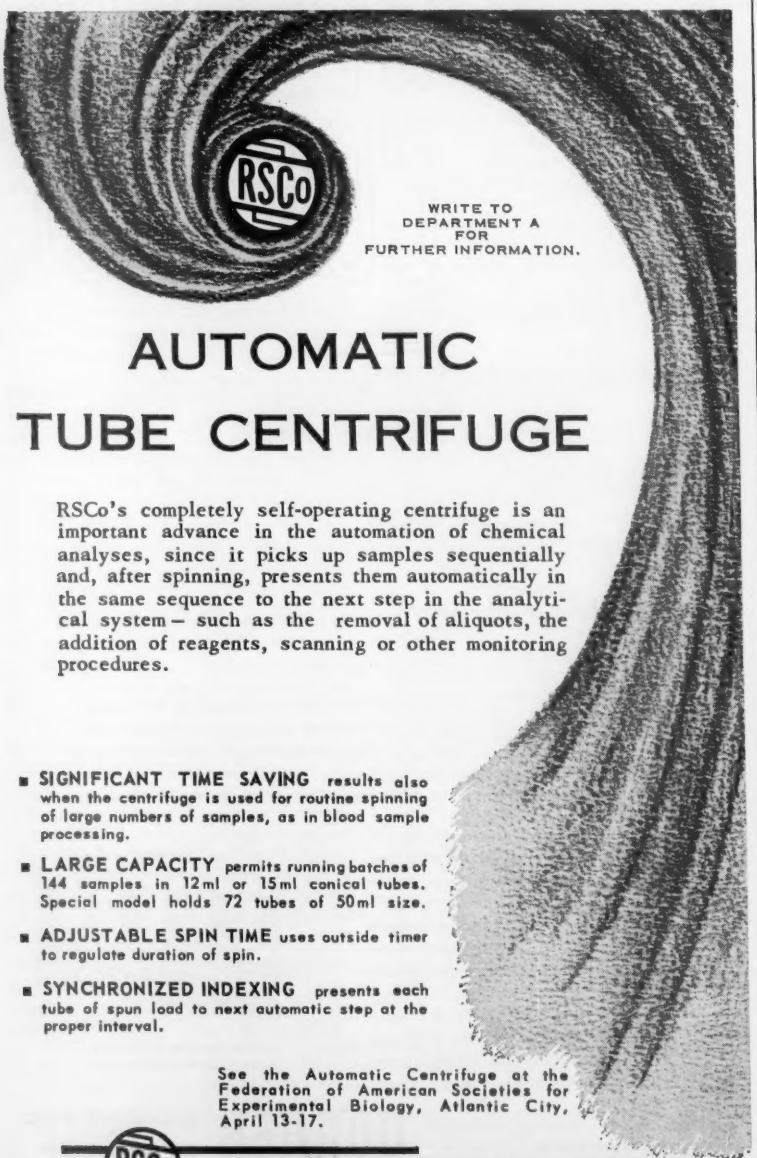
and animal skin have been in progress for a year. Further reports on cosmic ray effects were made by Jakob Eugster of Zurich, who made studies at sea level, high altitudes, and underground, and by J. E. Pickering of Randolph Field, who estimated some "permissible dose levels" for pioneer space fliers. Cosmic rays present definite hazards for the future space flier. However, the radiation belt can be avoided by selecting low or polar orbits, and it is conceivable that it will be possible to shield against it, at the same time cutting out the low-energy heavy primaries.

Fred L. Whipple of Harvard University described our knowledge of meteoritic material in space. The larger fragments originate in meteoritic zones of the solar system and are quite rare; interplanetary dust contains tiny particles originating from comets and ending up on the sun or on the planets. Dust counts from Russian and American satellites indicate that perhaps 3000 tons of dust fall on the earth daily. Falling through the atmosphere, the tiny particles may then act as condensation centers for rain and are thus a factor in meteorology.

John W. Townsend of the U.S. Naval Research Laboratory explained that at very high altitudes the air density is much higher than had been previously expected. A small portion of the solar corona appears to extend down to the earth. Hans Clamann of the School of Aviation Medicine and Marcel Nicolet of the Royal Meteorological Institute of Belgium discussed the chemistry of the upper atmosphere. Under the influence of sunlight the very noxious gas ozone forms. Ozone protects life at the surface of the earth from short-wave ultraviolet rays of the sun, which would otherwise be absorbed by nucleic acids and proteins and could be lethal. At altitudes above 100 kilometers, the air molecules ionize and dissociate. Free electrons and a variety of radical species appear—combinations of atoms N, O, and H. Whether or not thermal equilibrium is established at very low pressures is being questioned. There is an interaction between photochemical reactions and intermolecular action involving diffusion and collisions. At an altitude of 1000 kilometers, half of all molecular species are ions.

Walter Dieminger of the Max Planck Institute of Aeronomy, Göttingen, Germany, discussed the propagation of electromagnetic waves in the upper regions of the atmosphere. If the wavelength is below 5 meters, the atmosphere is quite transparent. Longer wavelengths are reflected and bent by the electron layers. The Russian satellites obtained particularly useful data in this field: the bending of the signals from the sputniks was correlated with electron density.

Thorough and detailed exposition was given to various phases of rocket engineering aimed at putting man into space. There is no doubt that existing rocket-propulsion systems are capable of lifting man into orbit. These were discussed by B. A. Schriever, U.S. Air Force. L. R. Shepherd, chairman of the council of the British Interplanetary Society, claimed that atomic propulsion may extend rocket capability to any place in the solar system. The most promising nuclear systems are reactor-heat exchanger, ion propulsion, and nuclear fusion. Many interesting phases of launching, tracking, cabin design, and reentry were discussed, by Wernher von Braun, Ernst Stuhlinger, Dean Chapman, and Krafft Ehricke, respectively. R. Wellner of the Bell Aircraft Corporation discussed the space plane or "rocket booster glider." A whole morning was devoted to the problem of emergency escape and rescue from a space vehicle, with discussions by P. A. Campbell, R. M. Stanley, Krafft Ehricke, N. V. Pedersen, and A. M. Mayo. Members of the staffs of the School of Aviation Medicine, the Wright Aero Medical Center, and the Lovelace Foundation—namely, R. T. Clark, G. R. Steinkamp, G. R. Hauty, S. J. Gerathewohl, W. R. Love-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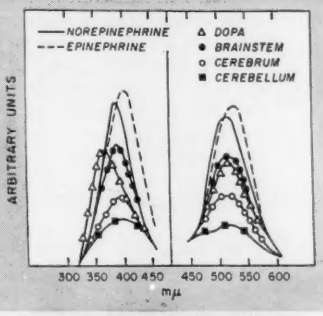
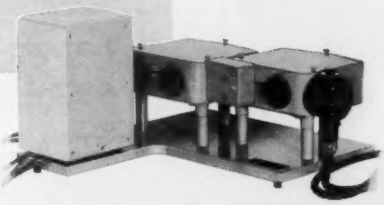


Activation spectra (left) and fluorescence spectra (right) of various catechols and rabbit brain extracts.

To obtain the activation spectra, the fluorescence monochromator of a Farrand Recording Spectrofluorometer was set at 520 mμ and the spectra from the activating monochromator were scanned. To obtain the fluorescence spectra, the activating monochromator was set at 400 mμ and the spectra from the fluorescence monochromator were scanned.

*Ref: *Parkhurst A. Shore and Jacqueline S. Olin, Journal of Pharm. and Experim. Therapeutics, Vol. 122, No. 3.*



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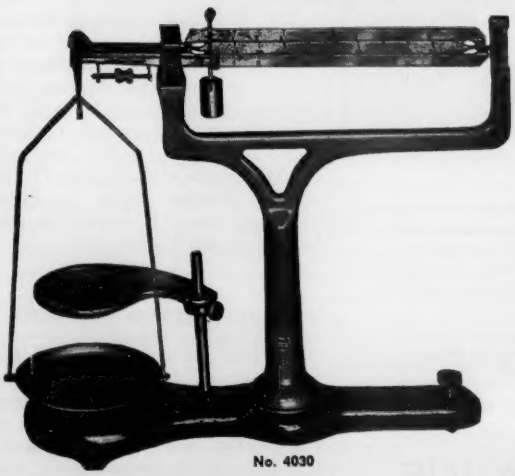

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lace, II, and J. P. Stapp—reported on parameters of human adaptation and stress, including factors such as anoxia, acceleration, weightlessness, heat, diurnal variation, and psychological stress. These studies, as well as the statement of Scott Crossfield, famous test pilot and design specialist, make it appear that, when the time comes, people will be available who can cope with the stress of orbital flight.

If man is to spend considerable time in interplanetary space or on a planet, he will have to take part of his environment along. He will have to produce on a small scale an ecological cycle comparable to that which now exists between plants, animals, and man on earth. This intricate problem was discussed by Jack Myers of the University of Texas and H. G. Clamann of the School of Aviation Medicine. The final solution should bring much greater insight into the science of bioecology than we now have.

A number of distinguished astronomers discussed the physics of the sun and the environment on the surface of the planets. Walter Orr Roberts of the University of Colorado discussed the role of sunspots and solar flares in terrestrial weather. G. P. Kuiper of the Yerkes and McDonald observatories showed the best photographs of the lunar surface yet made. Gerard de Vaucouleurs of Harvard University cited evidence for "life" on the planet Mars: infrared spectra obtained from scattered infrared rays from light and dark areas of the planet, which resemble spectra obtained from lichens. The problem of extraterrestrial life and of the origin of life is a very fascinating one which interests some of the most outstanding bioscientists. John D. Fulton of the School of Avi tion Medicine simulated Martian atmosphere, soil, moisture, and temperature conditions in his laboratory and found three different microorganisms which were still capable of multiplying. Further work, in the presence of solar radiation, is needed. Hubertus Strughold, the first professor of space medicine and the originator of many basic concepts of space biology, discussed the interactions of the gravitational fields of the sun, earth, and moon.

Many basic biological questions remained necessarily unanswered at the conference, among them that of the exact nature of life elsewhere in the solar system. When experiment can answer these questions, then the scope of our knowledge of life processes will be greatly widened. For nature is far more resourceful than we can imagine, and life may originate, exist, or adapt itself to environments in greater richness of forms than we know.

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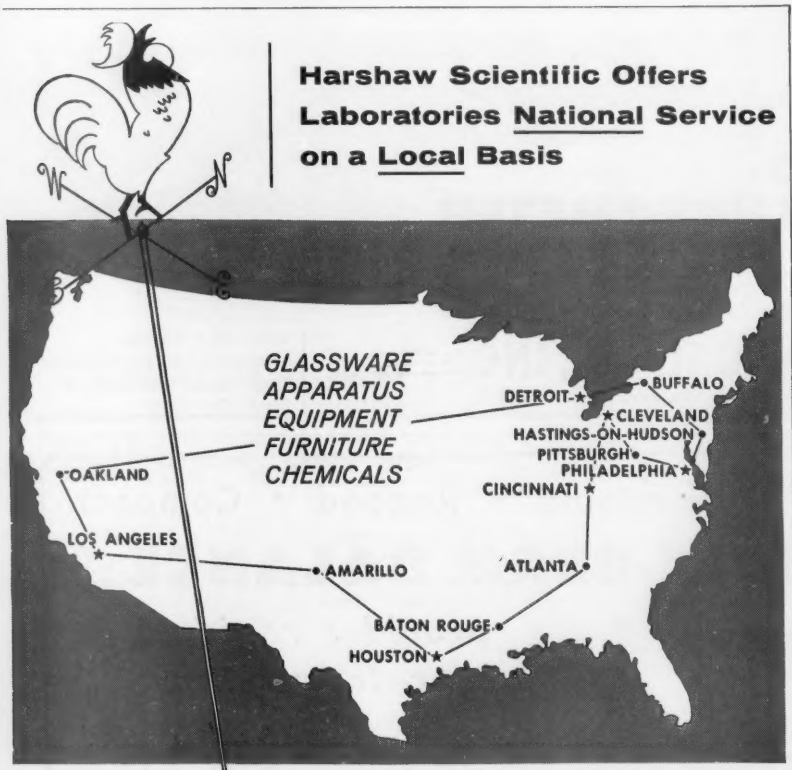

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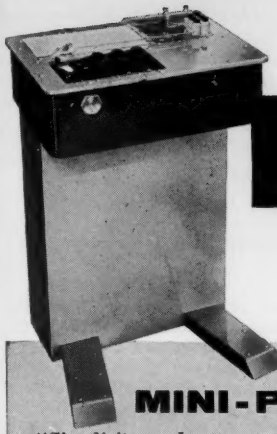
Differentiation

The Roscoe B. Jackson Memorial Laboratory, in celebration of its 30th anniversary, will hold a symposium 15–17 June at Bar Harbor, Me., on "Some Problems of Normal and Abnormal Differentiation and Development." Attendance will be limited to 100. Application should be made *not later than 15 April,* to: Dr. Nathan Kaliss, Symposium Chairman, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me.

Laurentian Hormone Conference

The 1959 Laurentian Hormone Conference of the AAAS will be held at Mont Tremblant Lodge, Mont Tremblant, Quebec, between 30 August and 4 September. Investigators interested in attending this conference should make application to the Committee on Arrangements of the Laurentian Hormone Conference, 222 Maple Ave., Shrewsbury, Mass., at an early date and in any event no later than *11 May.*

A conference rate of $13 per day per person is extended to all invited partici-



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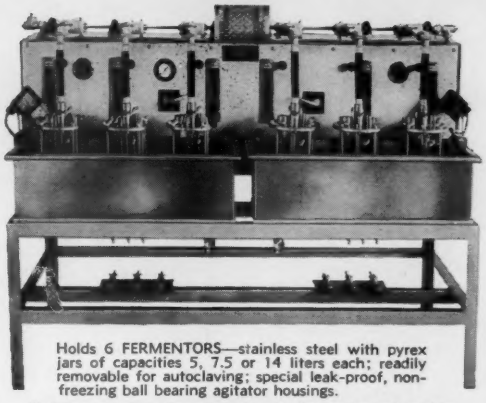

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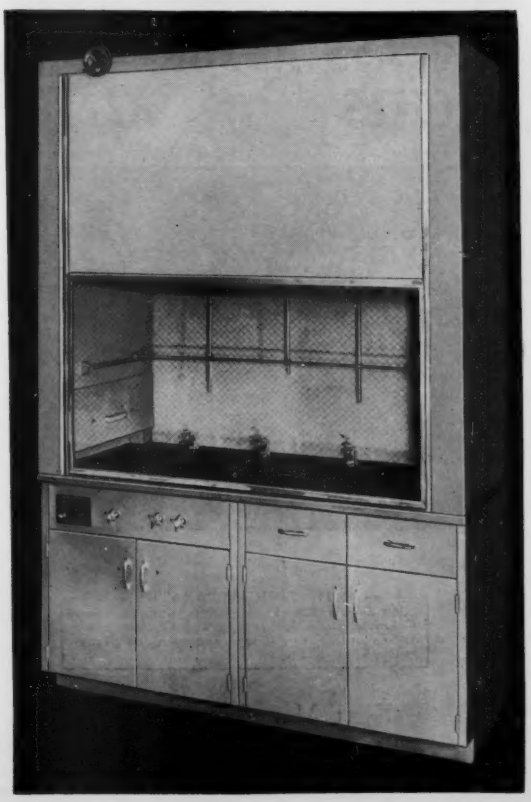

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pants. Since the number of participants is necessarily limited by available accommodations, all applications are screened and invitations to attend are issued by the Committee on Arrangements by 12 June.

Biophysics

Yale University will sponsor a conference on opportunities in biophysics research on 29 June–3 July at the J. W. Gibbs Laboratory under a grant from the National Science Foundation. The conference will be directed by E. C. Pollard, chairman of the biophysics department, with the assistance of Harold J. Morowitz.

During the last 18 months, visiting physicists have repeatedly pointed to the importance of providing research opportunities in physics in the smaller colleges. Physicists situated in these institutions need encouragement and assistance in carrying on small-scale, but significant research. Opportunities for research are often as important as the salaries offered in attracting competent young physicists to the staffs of colleges.

The Yale conference will review opportunities for college physicists in biophysics research. Other universities are considering similar conferences in other areas of physics.

Participants in the conference will receive stipends at the rate of $15 per day and travel allowances at the rate of about 4 cents per mile. Approximately 30 participants can be accommodated. The major criteria for their selection will be interest in conducting some form of research in biophysics, tenure of a teaching position in a small institution where expensive research equipment in physics would be hard to come by, and an advanced degree in physics. Inquiries about the conference should be directed to Professor E. C. Pollard, Department of Biophysics, Yale University, New Haven, Conn.

Wistar Institute Symposium

At the Symposium on the Structure of Science that will be held in Irvine Auditorium at the University of Pennsylvania, 17–18 April, national and international figures in science will suggest some possible directions for future scientific thought and activity. The symposium accompanies the formal opening of new laboratories and a new museum at the Wistar Institute of Anatomy and Biology in Philadelphia.

Senator Lister Hill of Alabama and LeRoy Burney, surgeon general of the U.S. Public Health Service, will join with physicists, philosophers, mathematicians, chemists, biologists, and research institute officials from the United States, Canada, England, and Sweden as speakers at the symposium.

Forthcoming Events

May

3. American Federation for Clinical Research, annual, Atlantic City, N.J. (G. E. Schreiner, Georgetown Univ. Medical Center, Washington 7.)

3. Periapical Lesions-Pacific Coast Oral Pathology Workshop, 1st annual, Los Angeles, Calif. (W. Bullock, Dept. of Pathology, Univ. of Southern California School of Medicine, 1200 N. State St., Los Angeles.)

3–7. American Assoc. of Cereal Chemists, 44th annual, Washington, D.C. (J. W. Pence, AACC, Western Utilization Research Laboratories, Albany, Calif.)

3–7. Electrochemical Soc., Philadelphia, Pa. (Electrochemical Soc., Inc., 216 W. 102 St., New York 25.)

3–7. Electrode Processes, symp., Philadelphia, Pa. (Headquarters, Air Force Office of Scientific Research, Washington 25.)

3–7. Mechanical Properties of Inter-

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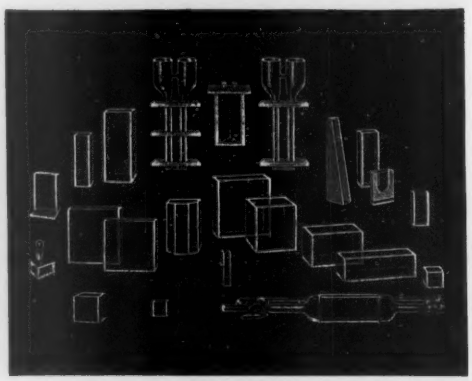

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metallic Compounds, Philadelphia, Pa. (J. H. Westbrook, General Electric Research Laboratory, P.O. Box 1088, Schenectady, N.Y.)

4. American Soc. for Clinical Investigation, annual, Atlantic City, N.J. (W. W. Stead, J. Hillis Miller Health Center, Gainesville, Fla.)

4–5. Microcirculatory Conf., 7th annual meeting, NIH, Bethesda, Md. (B. W. Zweifach, 550 First Ave., New York 16.)

4–7. American Geophysical Union, annual, Washington, D.C. (W. E. Smith, AGU, 1515 Massachusetts Ave., NW, Washington 5.)

4–7. National Instrumentation Flight Test Symp., 5th, Seattle, Wash. (H. T. Noble, Boeing Airplane Co., Flight Test Station, Wichita 1, Kan.)

4–8. American Soc. of Civil Engineers, Cleveland, Ohio. (W. H. Wisely, 33 West 39th St., New York 18.)

5–6. Association of American Physicians, annual, Atlantic City, N.J. (W. W. Stead, vice president, AFCR, J. Hillis Miller Health Center, Gainesville, Fla.)

5–6. Self-Organizing Systems, conf., Chicago, Ill. (S. Cameron, ICSOS Conference Secretary, Armour Research Foundation, 10 W. 35 St., Chicago 16.)

5–7. International Scientific Radio Union, spring meeting, Washington, D.C. (J. P. Hagen, National Acad. of Sciences, 2101 Constitution Ave., NW, Washington 25.)

5–9. Southwestern and Rocky Mountain Div., AAAS, Laramie, Wyo. (M. G. Anderson, New Mexico College of Agriculture and Mining, State College.)

5–12. Electronic Distance Measuring Equipment, Intern. Assoc. of Geodesy symp., Washington, D.C. (C. A. Whitten, Coast & Geodetic Survey, Washington 25.)

6–8. American Inst. of Chemists, Atlantic City, N.J. (L. Van Doren, American Inst. of Chemists, Inc., 60 E. 42 St., New York 17.)

6–8. American Pediatric Soc., Buck Hill Falls, Pa. (A. C. McGuinness, 2800 Quebec St., Washington 8.)

6–8. Metal-Binding in Medicine, symp., Philadelphia, Pa. (M. J. Seven, Hahnemann Medical College and Hospital of Philadelphia, 230 N. Broad St., Philadelphia 2.)

6–9. National Science Fair, 10th, Hartford Conn. (Science Clubs of America, 1719 N St., NW, Washington 6.)

6–10. Infectious Pathology, intern. cong., Milan, Italy. (A. Janussi, Secretary General, via Boccaccio 25, Milan.)

7–9. Midwestern Psychological Assoc., Chicago, Ill. (I. E. Farber, Dept. of Psychology, Univ. of Michigan, Ann Arbor.)

7–9. World Cong. on Agricultural Research, International Confederation of Agricultural Engineers and Technicians, Rome, Italy. (CITA, Regional Secretariat, 86, via Barberini, Rome.)

8–10. Uranium, 4th annual symp., Moab, Utah. (AIME, 29 W. 39 St., New York 18.)

9–11. International Soc. of Acupuncture, 10th cong., Paris, France. (SIA, 8 avenue Franklin Roosevelt, Paris 8e.)

10–15. Society of American Bacteriologists, St. Louis, Mo. (E. M. Foster, Univ. of Wisconsin, Madison 6.)

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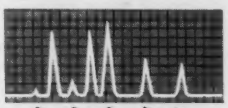

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10–14. American Soc. of Maxillofacial Surgeons, Chicago, Ill. (O. H. Stuteville, 700 N. Michigan, Chicago 11.)

11–12. Practical Problems of Coordinating and Integrating All Services Related to the Treatment, Training and Management of the Mentally Retarded, conf., Vineland, N.J. (J. D. Eadline, Training School, Vineland, N.J.)

11–13. Instrumentation and Computation in Process Development and Plant Design, symp., London, England. (Institute of Chemical Engineers, 16, Belgrave Sq., London, S.W.1.)

11–13. Microwave Theory and Techniques, natl. symp., Boston, Mass. (H. Pratt, Inst. of Radio Engineers, 1 E. 79 St., New York 21.)

11–13. Power Instrumentation, natl. symp., Kansas City, Mo. (H. H. Johnson, Consolidated Edison Co. of New York, Room 1515-S, 4 Irving Pl., New York 3.)

13–16. Human Biochemical Genetics, Ciba Foundation symp., London England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1.)

14–15. Operations Research Soc. of America, Washington, D.C. (H. J. Miser, Rt. 2, Box 211, Vienna, Va.)

14–16. Acoustical Soc. of America, Ottawa, Canada. (W. Waterfall, 335 E. 45 St., New York 17.)

14–17. American Acad. of Dental Medicine, 13th annual, Atlantic City, N.J. (H. A. Lentz, 619 Main Ave., Passaic, N.J.)

14–16. American Assoc. of Physical Anthropologists, Madison, Wis. (E. E. Hunt, Jr., Peabody Museum, Harvard Univ., Cambridge 38, Mass.)

17–20. American Inst. of Chemical Engineers, 40th natl., Kansas City, Mo. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

17–21. American Ceramic Soc., 61st annual, Chicago, Ill. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

17–21. Institute of Food Technologists, 19th annual, Philadelphia, Pa. (C. S. Lawrence, IFT, 176 W. Adams St., Chicago 3, Ill.)

17–23. Antibiotics, intern. symp., Prague, Czechoslovakia. (M. Heřmanský, Antibiotics Research Inst., Roztoky near Prague, Czechoslovakia.)

17–23. Mass Spectrometry, 7th, Los Angeles, Calif. (A. G. Sharkey, Jr., U.S. Bureau of Mines, 4800 Forbes Ave., Pittsburgh 13, Pa.)

18–20. Instrumental Methods of Analysis, 5th natl. symp., Houston, Tex. (H. S. Kindler, Director of Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

19–23. American Assoc. of Mental Deficiency, Milwaukee, Wis. (N. A. Dayton, Mansfield State Training School & Hospital, Mansfield, Depot, Conn.)

20–22. Education of the Scientist in a Free Society, conf., Milwaukee, Wis. (A. B. Drought, College of Engineering, Marquette Univ., 1515 W. Wisconsin Ave., Milwaukee 3.)

21–23. American Assoc. for the History of Medicine, 32nd annual, Cleveland, Ohio. (Miss E. H. Thomson, Yale Univ. School of Medicine, New Haven, Conn.)

(See issue of 20 March for comprehensive list)

Equipment

The information reported here is obtained from manufacturers and from other sources considered to be reliable, and it reflects the claims of the manufacturer or other source. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 918.*

■ TUNING-FORK OSCILLATOR provides any frequency from 400 to 10,000 cy/sec without dividers or multipliers. The transistorized device has a frequency tolerance ± 0.005 percent over the range −55° to +125°C. Output is 5 v r.m.s. across a 10,000-ohm load with essentially sinusoidal waveform. Supply power requirement is 6 or 30 v. Dimensions are 1½ by 1½ by 2¼ in. (Delta-f Inc., Dept. 652)

■ INFRARED ANALYZER is designed to measure water content in liquid or gas process streams. The ratio of transmission at two wavelengths is measured. Interference filters are used to isolate the two wavelengths, and a photoconductor is used to detect infrared radiation. (Analytic Systems Co., Dept. 711)

■ RECORDER provides analog recording with frequency response 0 to 100 cy/sec and 10 channels of event recording. Eight chart speeds are remotely or locally selectable. Sequence response is up to 500 signal changes per second. Operation is on 120-v, 60-cy/sec power. (Brush Instruments, Dept. 712)

■ VOLTAGE REFERENCE has a dual output of ± 50 v in one model and ± 36 v in a second. Total adjustment range is ± 120 mv around the nominal output voltage. Stability is ± 20 parts per million for 8 hr and ± 50 ppm long-term over the load range 0 to 100 ma and input voltage range 105 to 125 v. Temperature response is less than 2 ppm/°C at 25°C. The reference element is a Zener diode. Diode and preamplifier are contained in an isothermal oven. Calibration against an internal reference cell is provided. (Julie Research Laboratories, Inc., Dept. 713)

■ OSCILLOSCOPE with 17-in. screen features 1 percent linearity on both *x*- and *y*-axes. Amplifier sensitivity is 10 mv up to 500 kcy/sec. Magnetic deflection is used. (Eastern Precision Resistor Corp., Dept. 714)

■ VACUUM-TUBE VOLTMETER measures over the frequency range 10 cy to 4 Mcy/sec. Voltages from 0.001 to 300 v are measured in 12 ranges. Accuracy is stated to be ± 2 percent. Indication is r.m.s. value of sine wave. (Republic Electronic Industries Corp., Dept. 716)

■ THROMBELASTOGRAPH makes simultaneous visual and photokymographic observations of three different samples of blood or plasma, giving a permanent record of the coagulation process. The instrument automatically records changes in viscosity and elastic properties of the clot during all phases of the coagulation process. The tracings give a picture of the formation or reduction of fibrin as continuously obtained from a single blood sample. After specimens have been introduced, procedure is completely automatic. (American Hospital Supply Corp., Dept. 721)

■ CURRENT INTEGRATOR is designed for use with high-voltage particle accelerators. Current ranges from 3 na to 1 ma are covered by 12 switch settings. A presetting feature permits the device to provide a warning signal when a specific amount of charge has been collected. An internal current source provides calibration. (Elcor, Inc., Dept. 715)

■ VACUUM SLIDE RULE provides scales for calculations relating pump speed, volume of system, pressure achieved, conductance of tubing, and evacuation time. Tables of unit-conversion factors and barometric-pressure-versus-altitude data are also included. (Central Scientific Co., Dept. 730)

■ GAUSSMETER is a nuclear-magnetic-resonance instrument for measurement of strength and homogeneity of stable or slowly changing magnetic fields. The instrument consists of a probe, an oscillator, and an indicator. A standard probe covers the range 300 to 20,000 gauss. Probes for other ranges are available. The standard probe contains Li^7 and H^1 nuclei in a volume of 0.14 cm^3, so that two distinct frequencies in separate frequency ranges are available. (Harvey-Wells Electronics, Dept. 726)

■ X-Y RECORDER uses two orthogonal mirror galvanometers to attain writing speeds greater than 2500 m/sec and frequency response flat to 100 cy/sec. Traces are recorded on ultraviolet-sensitive charts with recording area 8 by 8 in. The light source is a high-pressure mercury arc. The traces are visible almost immediately; exposure in normal room light completes the developing process. Standard photographic fixing processes may be used to make the record permanent. Inputs for each axis are supplied by interchangeable preamplifiers. Basic sensitivities are 0.625 v/in. and 31.25 mv/in. with d-c coupling preamplifiers. (Sanborn Company, Dept. 719)

JOSHUA STERN
National Bureau of Standards, Washington, D.C.

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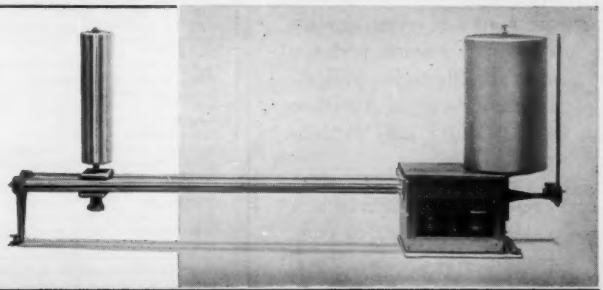

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The characteristics required in research or classroom demonstrations are featured in this kymograph. A combination of five gear shifts and a variable transformer Universal series motor makes available speed ranges of nine thousand to one. The approximate maximum speed is 400 cm. per minute and the minimum .045 per minute. Any speed within this range may be selected.

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Anatomist, Ph.D., 31; 5 years' teaching-research professor, histology, embryology. Desires academic affiliation affording opportunity to pursue M.D. degree. Box 81, SCIENCE. X

Biochemistry-Physiology, Assistant Professor. Currently sabbatical replacement in high-ranking liberal arts college. Desires position in institution preferably with graduate program and offering opportunities in research. Postdoctoral training (University of Chicago) and current research interests in protein and enzyme chemistry. Married. Interview Spring Federation meetings. Available September 1959. Box 76, SCIENCE. X

Botanist, woman, 7 years' full-time teaching experience, desires teaching position in senior college or university for summer of 1959. Radioisotope research in plant physiology. Box 72, SCIENCE. X

Experienced Bacteriologist, Ph.D. Agricultural, household, medical, and sanitary; also parasitology. Box 73, SCIENCE. X

Experimental Pathologist, D.V.M., Ph.D., teaching experience, publications, societies. Desires primarily research position. Box 77, SCIENCE. X

Histologist, Ph.D., seeking teaching-research post in Canada, September 1959. Will assist in neuroanatomy; eight publications in histochemistry. Box 83, SCIENCE. X

Medical Photographer (Chief) desires to relocate. B.S., M.A.; 11 years' experience in photomicrography, patient and specimen photography; surgical and public relations motion pictures, sound and silent. Will organize new photography laboratory or take over existing one. Box 79, SCIENCE. X

M.D., Ph.D. (physiology), 32. American, married, now completing internship, desires career in postclinical investigation. Broad interests; would enjoy some teaching. No military obligations. Box 56, SCIENCE. 3/20, 27; 4/3

M.D., recent graduate experienced in histology, biology, desires research and/or teaching position in department of anatomy, biological station, and so forth, or to join research team in need of morphologist. Box 78, SCIENCE. X

Microbiologist, Ph.D., biochemical background, experience, publications, desires academic position. Box 69, SCIENCE. X

Microbiologist, Ph.D.; 6 years' teaching, Research experience. Desires teaching-research position. Box 82, SCIENCE. X

Ph.D., zoology; man, 20 years' college experience. Prefers liberal arts college. Box 74, SCIENCE. X

Physiology-Endocrinology, Ph.D. Assistant professor of cell, mammalian, endocrine physiology. Academic or research. Box 75, SCIENCE. X

Psychologist, Ph.D., 5 years varied experience seeks research, clinical or academic position in New York City area. Box 65, SCIENCE. X

POSITIONS WANTED

Zoologist. Interests: invertebrates, limnology, parasitology. Teaching experience; publications; pre- and postdoctoral fellowships. Desires academic or research position. Box 66, SCIENCE. X

Research Administrator. Ph.D.; 18 years' diversified experience in chemical and biological research and technical administration; 8 years in pharmaceutical industry. Box 84, SCIENCE. 4/10

Research Administrator; Ph.D. (major, organic chemistry; minors, pharmacology, toxicology); broad experience as director of research and development. Medical Bureau, Burneice Larson, Director, 900 North Michigan, Chicago. X

Scientific Photographer, medical illustrator, supervising and teaching x-rays in six languages; long experience in all fields, desires change (position in science, education, industry). Excellent background, best references. Write Box 64, SCIENCE. 4/3

Veterinarian, M.S., 35. Background in clinical pathology, small animal medicine, and research in bovine mastitis. Desires position, preferably academic. Box 71, SCIENCE. X

POSITIONS OPEN

Assistant Professor of Biology, Ph.D. for fully accredited liberal arts college in Midwest. Strength in botany preferred. Salary at least $5000 to start. Research encouraged but not required. Box 85, SCIENCE. X

Assistant to Director of Research for expanding company in the East. Outstanding opportunity for scientist who prefers administrative work. Would be responsible for business aspects of a growing research division. Ph.D. or equivalent desirable. Experience in original laboratory work essential, preferably in pharmaceutical industry. Send résumé of education and experience. Box 68, SCIENCE. 4/3

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ARMOUR RESEARCH FOUNDATION of Illinois Institute of Technology
10 West 35 Street, Chicago 16, Illinois

Biochemist or Physiologist. Biochemist or physiologist with biochemical orientation to participate in studies on cardiovascular-renal physiology. Experience in tissue analysis and isotope techniques desirable. May Institute, 421 Ridgeway Avenue, Cincinnati 29, Ohio. 3/6, 4/3

Botanist-Bacteriologist. Ph.D. or equivalent, to teach bacteriology and some botany. Rank of assistant professor. Write Professor W. B. Stallworthy, Department of Biology, Mount Allison University, Sackville, New Brunswick, Canada. ew tf

Pharmaceutical Product and Development Supervisor to be responsible for independent research for the development of new and improved products. Future in a newly formed department. Experience in pharmaceutical production or development desirable. Submit résumé, available interview dates, and salary requirement, in confidence to Director of Pharmaceutical Research, Anchor Serum Company, St. Joseph, Missouri.

Postdoctorate Traineeship with possible academic future in medical research concerning host responses to infectious diseases: involving pathology, endocrinology, immunology and biochemistry, at major eastern medical school; interest in experimental pathology for its own sake essential. $5000–$6000. Box 70, SCIENCE. 4/10

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Applications, accompanied by a recent photograph or snapshot and giving age, nationality, and other personal information; list of publications, and names and addresses of three references, should be submitted to the Head, Department of Plant Science, University of Alberta, Edmonton, Alberta, CANADA. Closing date: 1 June 1959. 4/10

UNIVERSIDAD NACIONAL DEL SUR
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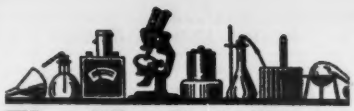

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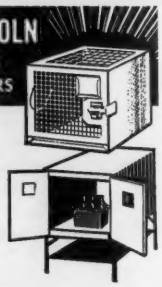

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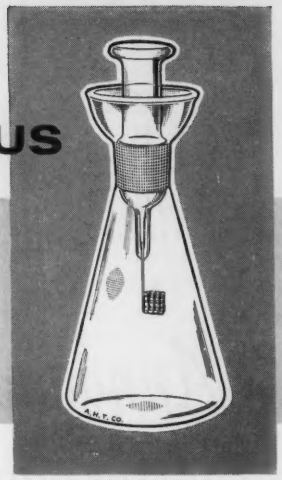

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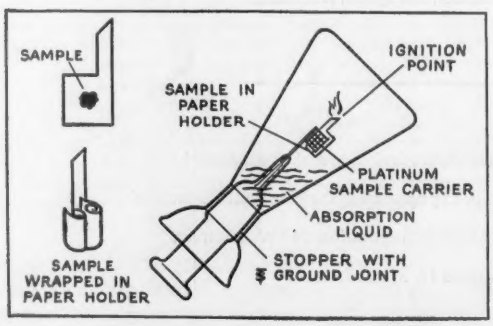
In use, the sample is wrapped and folded in the paper with the narrow tail extending for ignition. Sample is then placed in the platinum carrier and the flask is charged with a small amount of absorbing liquid as required for the specific reaction and with free-flowing oxygen. The paper tail is then ignited; the stopper with flaming sample is seated in the flask and flask then inverted at an angle. The catalytic combustion proceeds at high temperatures and the combustion products are absorbed in the liquid, which forms a seal around the stopper. After cooling, the inside surfaces of the flask and stopper are thoroughly rinsed. *Titrations can then be made directly in the flask.*

Due to the inherent fragility of glass in the presence of reduced pressure, general safety regulations should be followed, such as the use of shield, goggles, etc.

Results compare favorably, i.e., within ±0.3%, with conventional combustion or decomposition methods. The method has been used extensively for analysis of the above elements but, because of the low cost, time and space saving features, is finding wide use for other substances which undergo complete combustion.

See Wolfgang Schöniger, *Mikrochimica Acta, 1955, Heft 1, pp. 123-129;* and ibid. *1956, Heft 1-6, pp. 869-876.* See also Kenneth D. Fleischer et al, *Analytical Chemistry, Vol. 30, No. 1 (Jan., 1958), pp. 152-153,* and Ihor Lysyj and John E. Zarembo, *Analytical Chemistry, Vol. 30, No. 3 (Mar., 1958), pp. 428-430.*



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